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SPACELAB

PAYLOAD ACCOMMODATION HANDBOOK

SLP/2104

APPENDIX B STRUCTURE INTERFACE DEFINITION MODULE

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EUROPEAN SPACE AGENCY

SPACELAB

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APPENDIX B – STRUCTURE INTERFACE DEFINITION

MODULE

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1. SCOPE

The Structure Interface Definition Appendix B defines the mechanical interfaces between Spacelab and its payload. The envelopes available for mounting payload hardware are specified together with the standard structural attachment interfaces.

Overall load capabilities and the local load capabilities for individual attachment interfaces are defined for the standard mounting locations. For mounting arrangements where the load capabilities are not easily presentable in tabular or graphic form, or where individual analyses may be necessary on a case-by-case basis, the available analytical tools are briefly listed. The mechanical environment is defined. Mechanical interfaces between the payload and the EPDS, CDMS and ECS are also included.

2. CONTENTS OF THE DOCUMENT

The experiment may interface structurally with the following Spacelab / Orbiter hardware :

- Aft Flight Deck
- Module
 - Racks
 - Floor
 - Center Aisle
 - Overhead Structure
 - Containers
 - Common Payload Support Equipment
 - Experiment Vent Assembly
- Pallet
 - Hardpoints/Substructure
 - Panels
 - Cold Plates/Cold Plate Support Structure
- Instrument Pointing System
 - Payload Integration Ring
 - Payload Clamp Assembly
 - Optical Sensor Package

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3. Module

A general overview of the module interior is given in Figure 3.1 - 1. Standard structural Spacelab/experiment interfaces are provided to accommodate equipment at

- the experiment racks
Spacelab provides single and double racks for the accommodation of 19" type of equipment. In the racks ECS, EPDS, and CDMS services for experiments are foreseen
- the module floor
the center aisle is dedicated to experiments and provides ECS, EPDS, and CDMS services for experiments.
the side floor available for experiments at locations where racks are normally flown.
the underfloor area in the experiment segment of the module can be used for experiments by means of a user provided subfloor (see also para. 3.3.3.3).
- the overhead structure
experiments can make use of the overhead stowage containers and experiment rack attachment points at the overhead structure whenever the stowage containers and racks are not installed
- the stowage containers
Spacelab provides rack mounted and overhead mounted stowage containers for experiment equipment.
- the common payload support equipment (CPSE)
Spacelab provides an airlock with EPDS and CDMS services for experiments, a high quality window/viewport assembly and a viewport assembly with mechanical attachment provisions.

The module also provides interfaces for

- the experiment vent assembly
to dump gases from experiments into space by means of an experimenter provided vent line
- the module connector brackets
which provide interfaces to CDMS and EPDS on module level
- experiment utility routing provisions
which allow the routing of utilities under the main floor from experiment to experiment or Spacelab subsystems. There are also provisions to route a vent line and to route liquid lines to the experiment heat exchanger.

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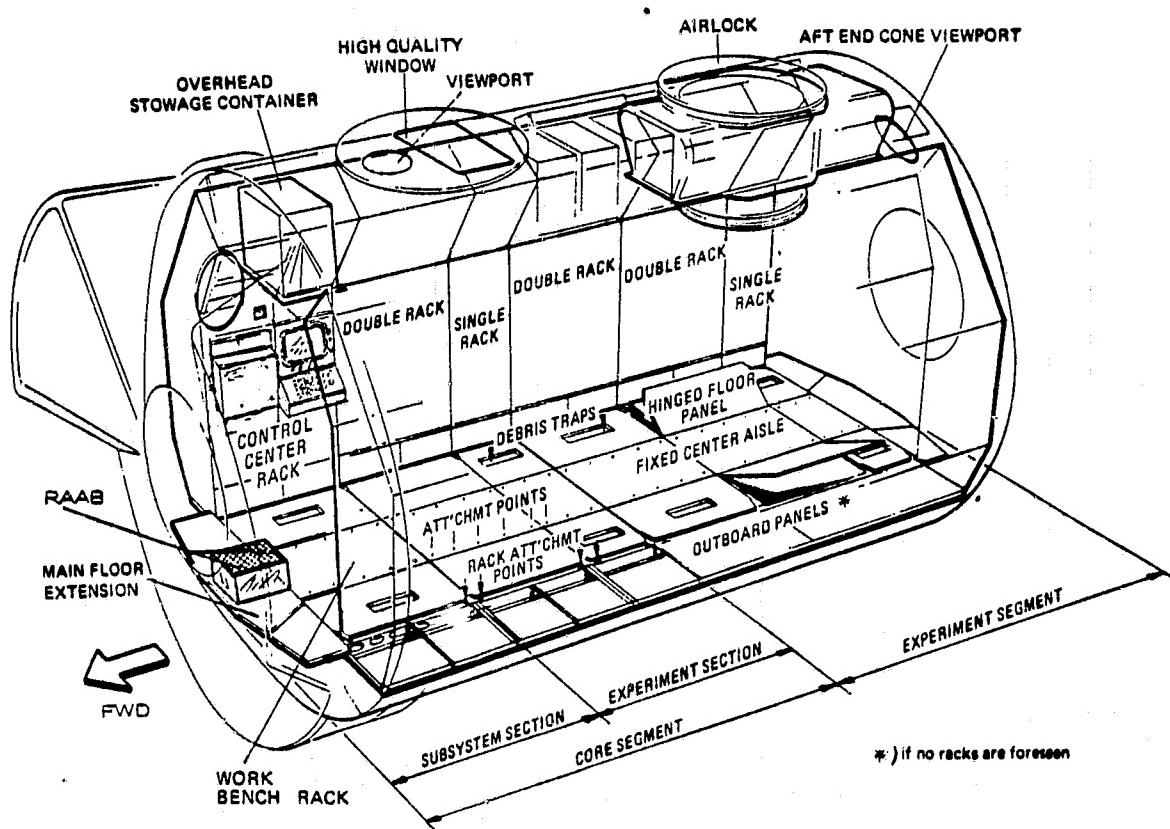


Figure 3.1 - 1 : General Overview

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3.1 Module Characteristics

3.1.1 Module Payload Envelopes

For reference the overall accommodation geometry of the short and long module as well as the main payload envelopes are shown in Figures 3.1 - 2a and 3.1 - 2b.

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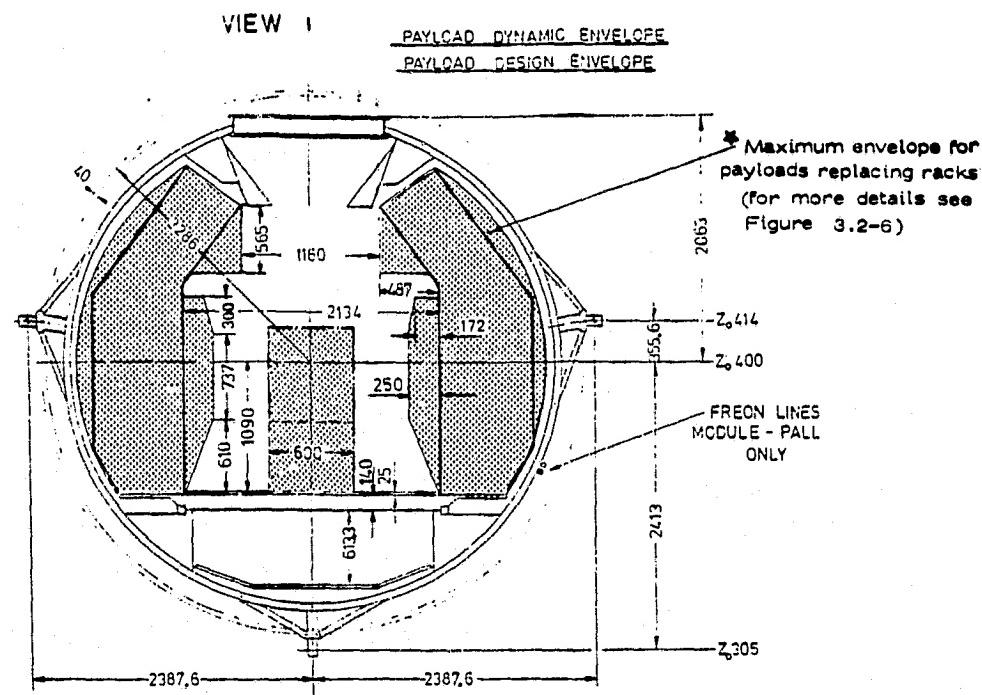
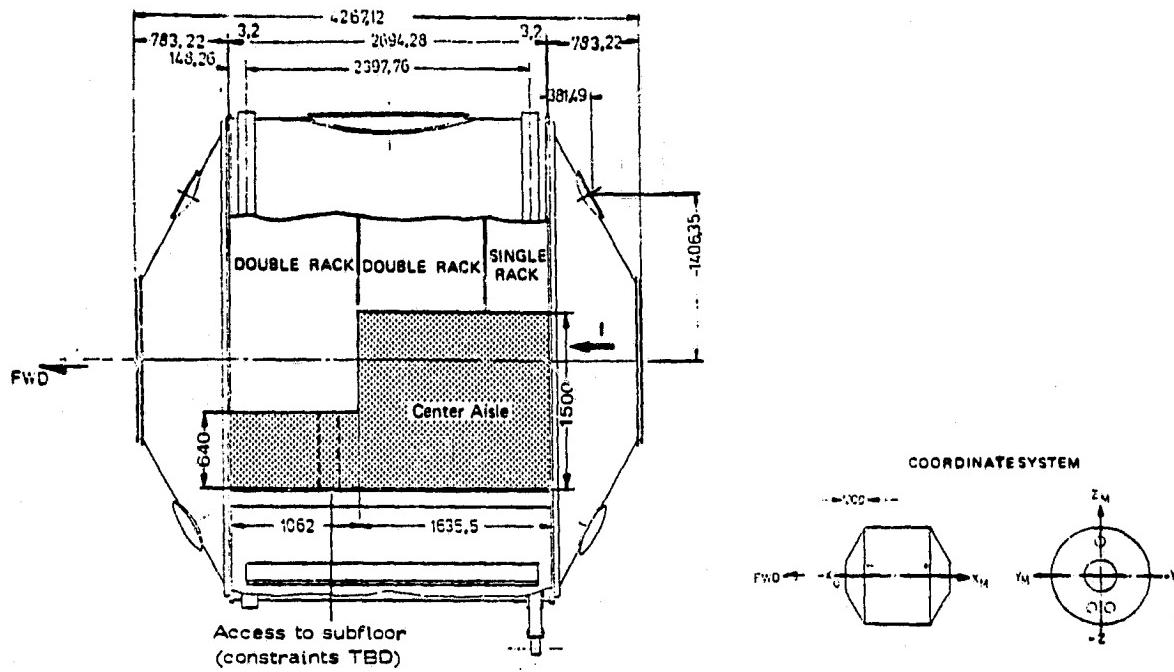
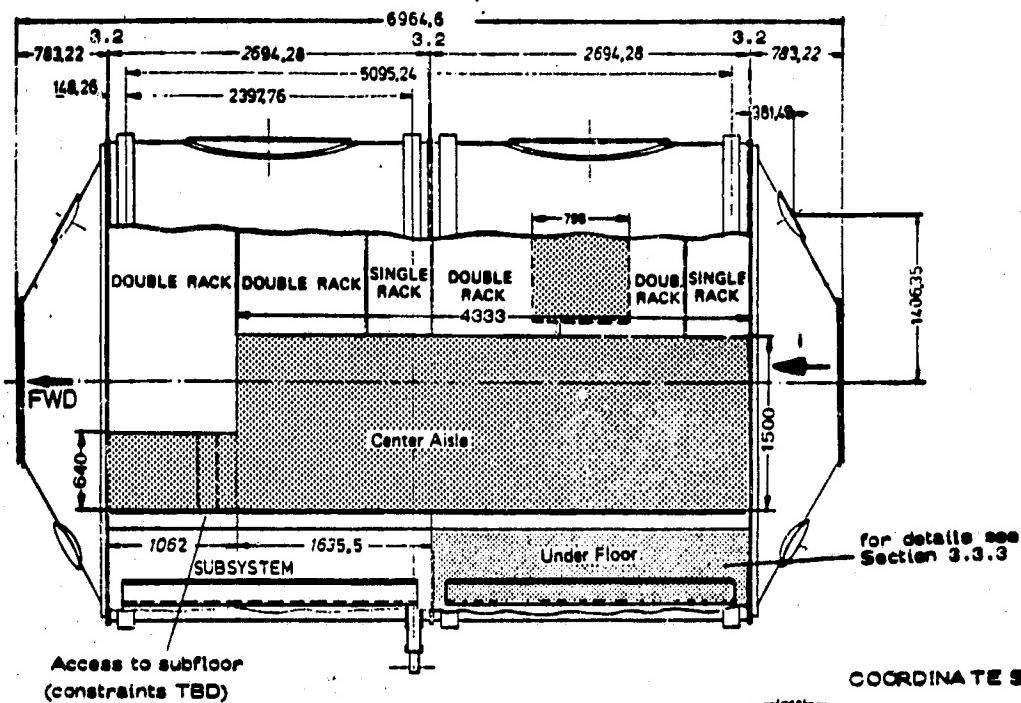


Figure 3.1 - 2 a : Main Dimensions of the Short Module



COORDINATE SYSTEM

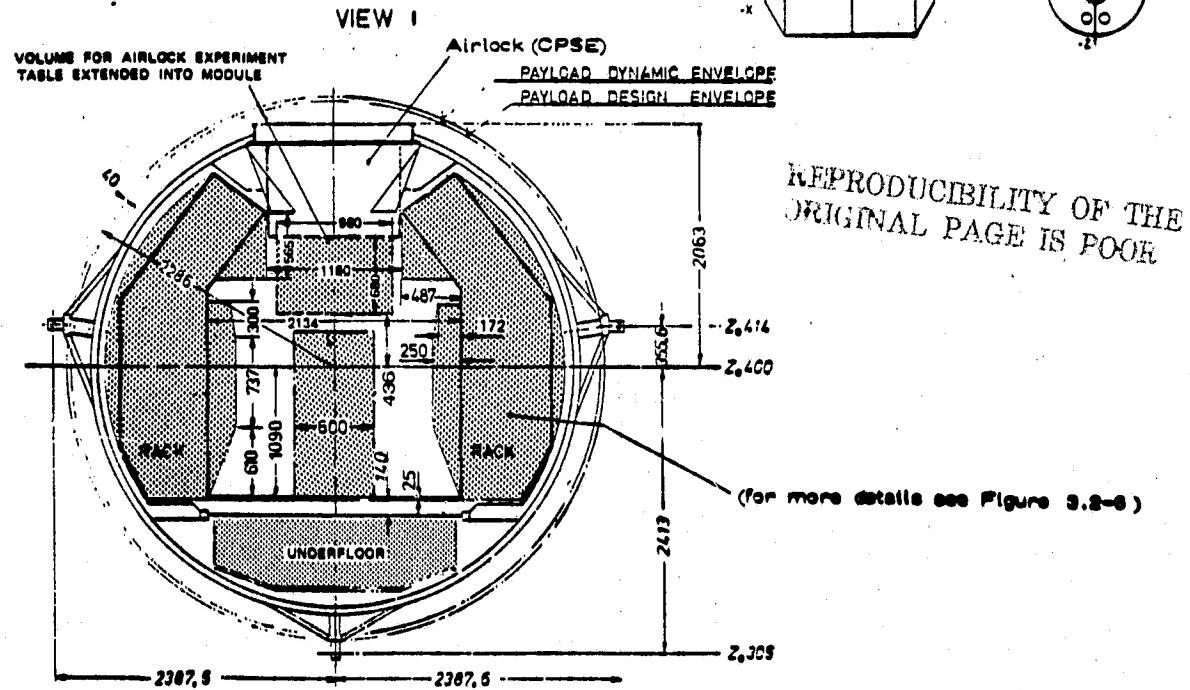
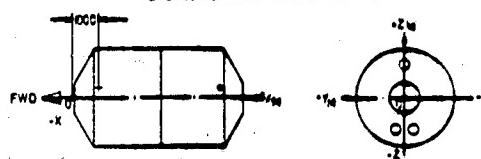


Figure 3.1 - 2 b : Main Dimensions of the Long Module

3.1.2 Module Location Identification System

A location identification system has been established for crew orientation in the module. The system used for Spacelab subsystems is also applicable for experiment equipment.

The location identification should not be confused with the rack numbering system as defined in Section 3.1.2.1.

3.1.2.1 Location Identification Code

The location is identified by an alphanumeric code. This code depicted in Figure 3.1 - 3 is based on the following groundrule:

- Forward end cone (F) and aft end cone (A) locations are identified by a grid coordinate system having a number 0 to 10 for distance from left to right as viewed and a letter for height from top to bottom.
- Overhead stowage containers (O) numbered 1 through 14 from fore to aft (e.g. O12).
- For the rest the module is divided into 12 slices along the cylinder axis starting with 0 for the forward endcone volume, followed by 1 through 10 representing slices of single rack thickness and 11 being the aft end cone volume.

A prefix letter denotes the location in the Y-Z plane:

The right and left side of the deck (main floor) is coded DR and DL

The right and left side of center aisle equipment is coded CR and CL

The right and left side of the underfloor is coded UR and UL

Racks on the right and left side are coded R and L. For racks a suffix letter determines the height counting from top to bottom.

The decoding of the location identifier is given below

example	R	9	G
Prefix	Number	Suffix	
O = Overhead container	1...14 fore to aft	-	
F = Forward end cone	1...10 left to right	A...Z top to bottom	
A = Aft end cone			
R = Rack right side	1...10 fore to aft	A...Z top to bottom	
L = Rack left side			
DR = Deck right side	0...11 fore to aft	-	
DL = Deck left side			
CR = Center aisle right	0...11 fore to aft	-	
CL = Center aisle left			
UR = Underfloor right	0...11 fore to aft	-	
UL = Underfloor left			

The example alphanumeric code identifies the location of the Intercom Remote Station in the upper right part of rack 10.

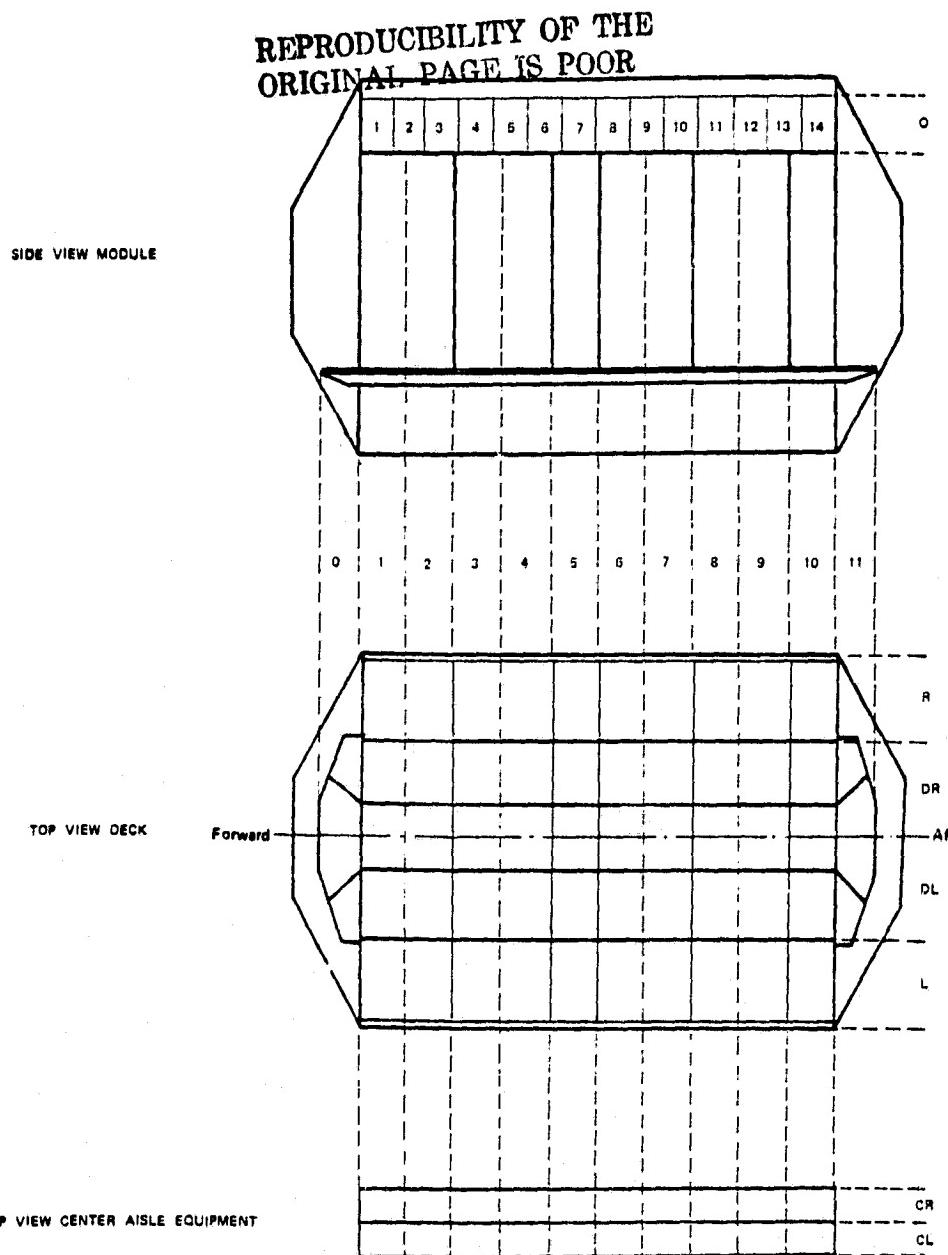


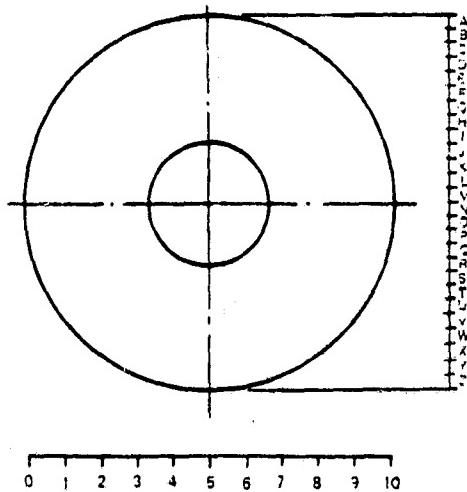
Figure 3.1 - 3a: Location Identification

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FRONT VIEW ENDcone



SIDE VIEW RACK

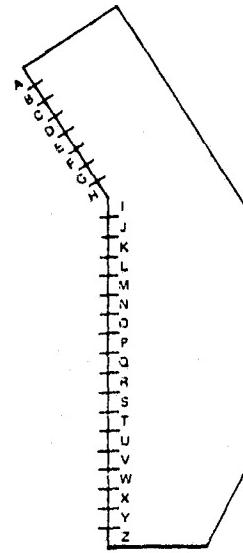
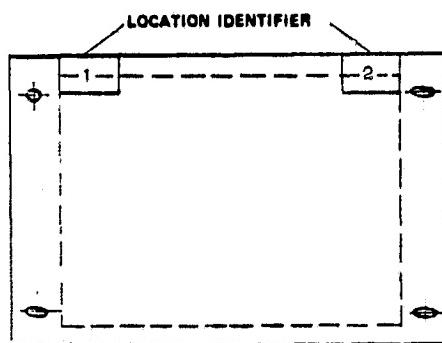


Figure 3.1 - 3b: Location Identification

3.1.2.2 Location Identifier on Front panels

The location identifier tagging will be performed by the mission operator. The experimenter has to reserve space on the front panels of his equipment for a location identifier decal as shown in Figure 3.1 - 4. Required is an area of $12 \times 27 \text{ mm}^2$ preferably in location 1. As a back up location 2 is acceptable.



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Figure 3.1 - 4: Locator Coding System

An example showing how the location identification is performed on Spacelab subsystems is shown in Figure 3.1 - 5.

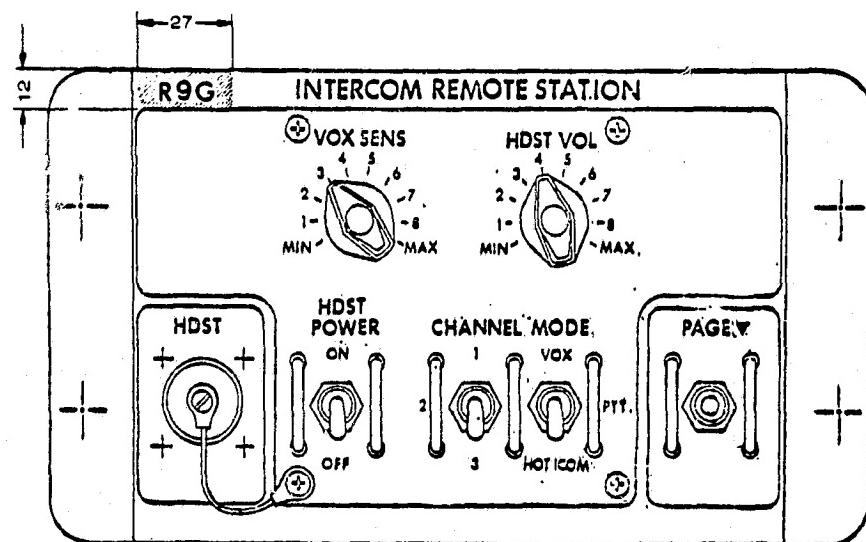


Figure 3.1 - 5: Example-Locator Coding System

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3.2 Experiment Racks

3.2.1 Rack Characteristics

Experiment racks are standard 19 inch racks to accommodate standard as well as non - standard laboratory equipment. The total number of experiment racks is two double and two single racks in the core segment and four double and two single racks in the experiment segment.

Experiment racks are mission dependent Spacelab subsystem equipment and can be removed, if required. In this case, experiment equipment can be mounted at the same attachment points of the racks on the floor and the overhead structure (see also section 3.3.2 and 3.4) within the envelopes shown in Figure 3.1 - 2a and 3.1 - 2b.

Figure 3.2 - 1 indicates the locations and the numbering system of the racks in the module. Rack 1 and Rack 2 are reserved for subsystem equipment.

The experiment racks are available for experiments and the following Spacelab Mission Dependent subsystem Equipment (MDE) :

- Experiment power switching panels; one in each rack is foreseen.
- Remote Acquisition Units; one in each rack may be accommodated.
- Experiment heat exchanger and one experiment dedicated cold plate; both located only in the experiment rack no. 4 adjacent to the control center rack.
- Remote Intercom Stations, located only in the racks no. 4, 7 and 10.
- Air cooling system.

Three dimensional views of single and double racks are given in Figures 3.2 - 2 thru 3.2 - 4. The contents of the experiment racks are compiled in Table 3.2 - 1.

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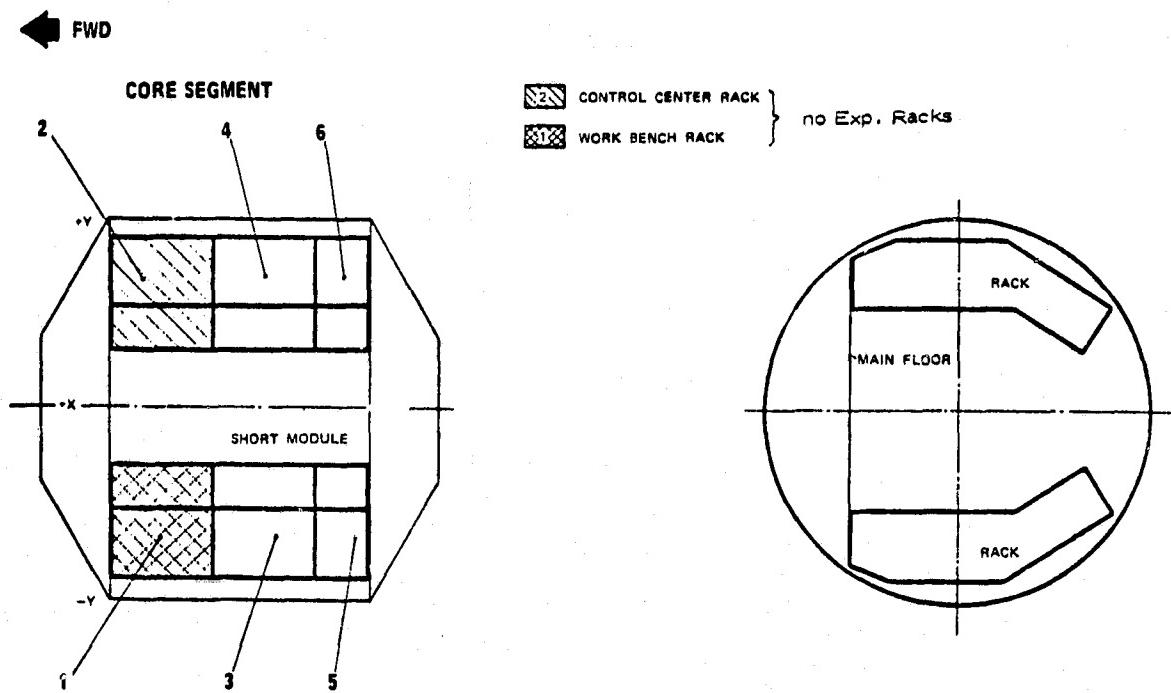
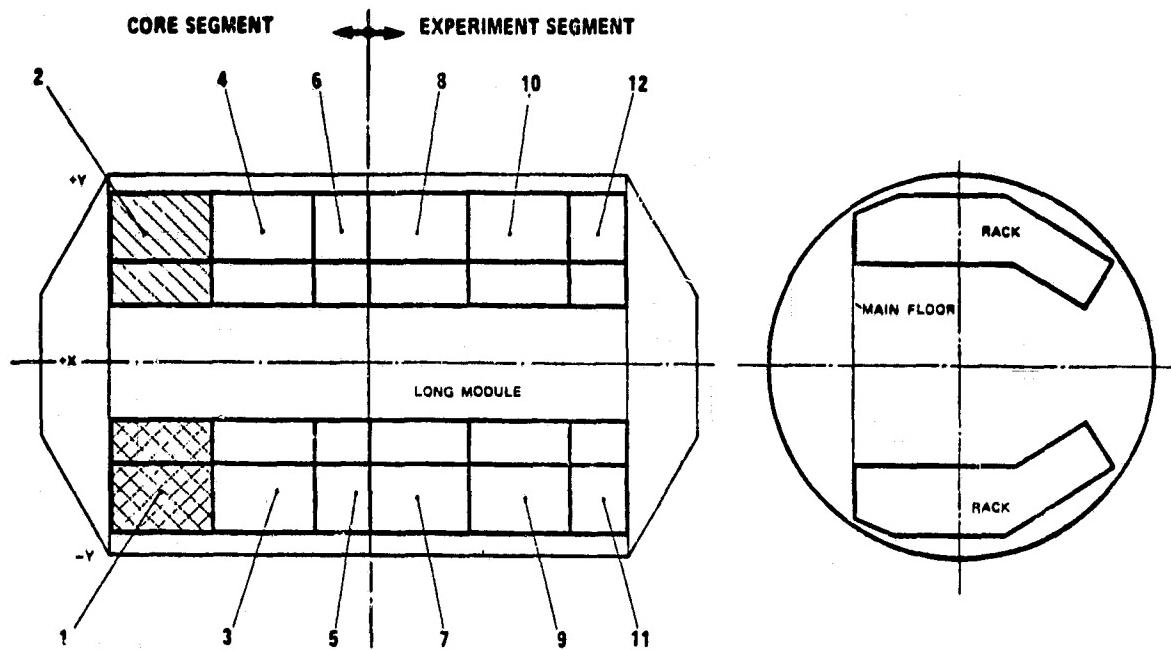


Figure 3.2 - 1: Rack Numbering System

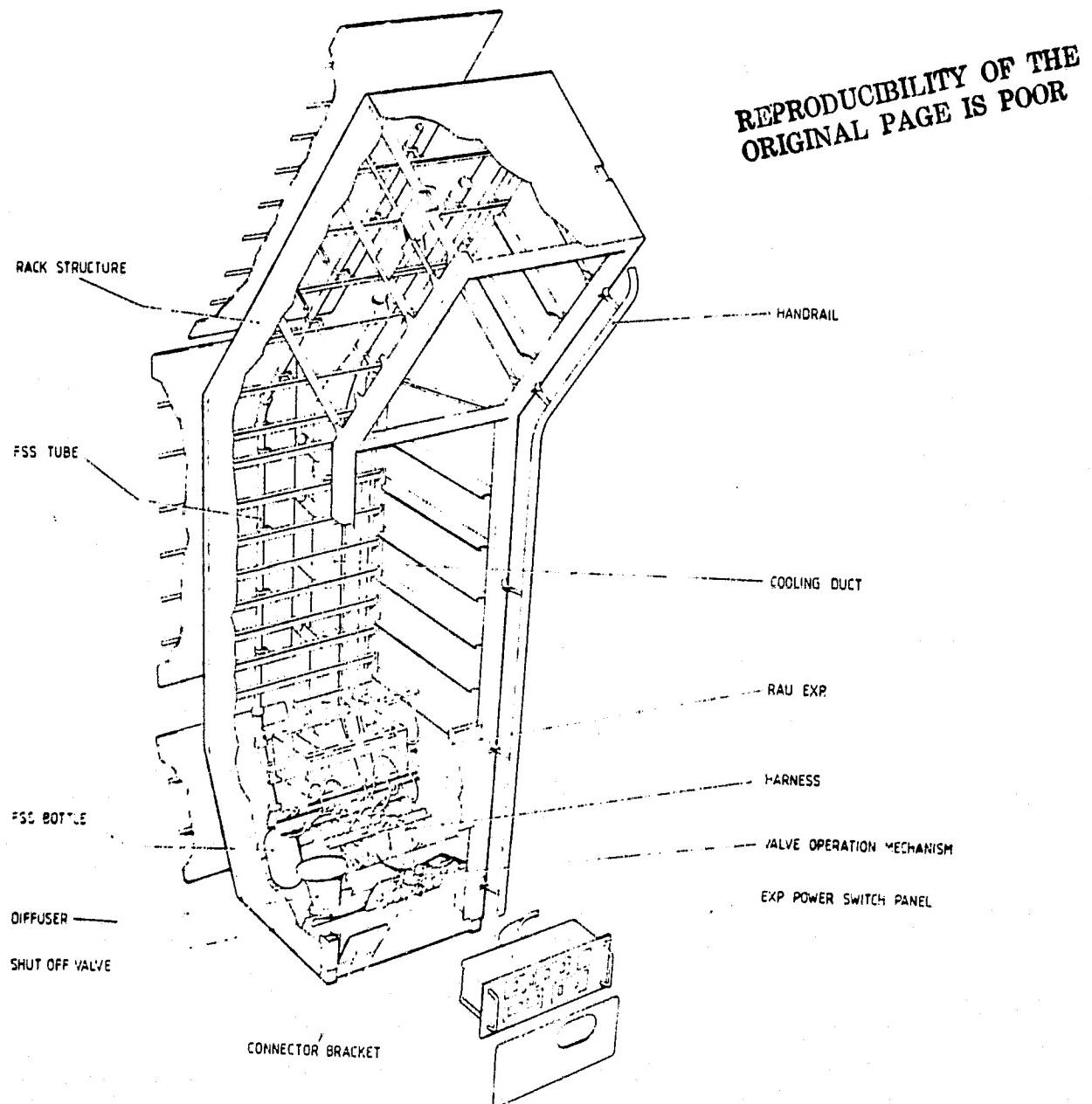


Figure 3.2 - 2: Experiment Single Rack, Three-Dimensional View

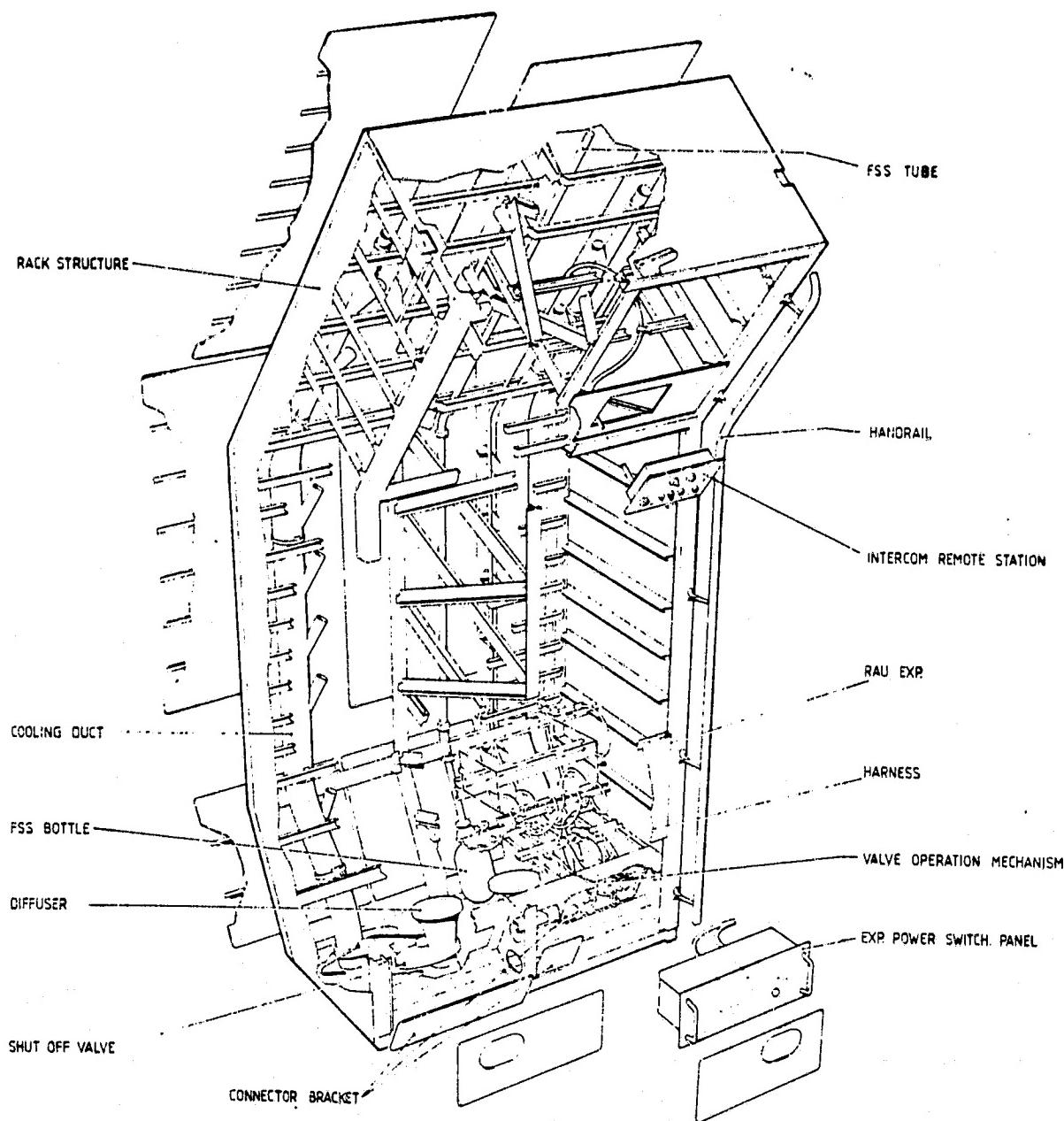


Figure 3.2 - 3: Experiment Double Rack,
Three-Dimensional View

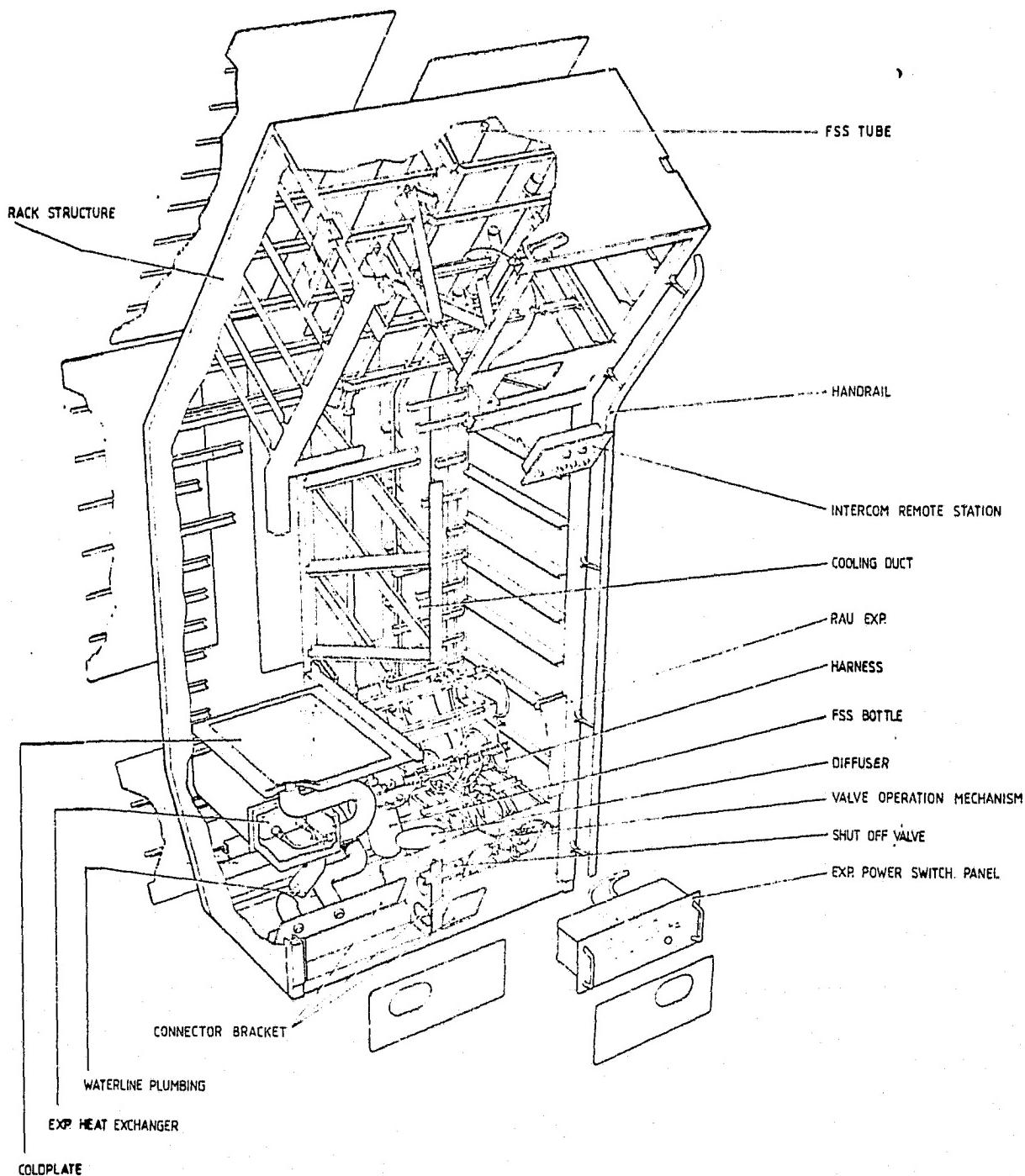


Figure 3.2 - 4 : Experiment Double Rack 4,
Experiment Module Coldplate and
Experiment Heat Exchanger Installed

Table 3.2-1 Parts and Components of Experiment Racks

	Single Rack				Double Rack					
	5	6	11	12	3	4	7	8	9	10
Structure										
Main frame	1	1	1	1	1	1	1	1	1	1
Side wall	2	2	2	2	2	2	2	2	2	2
Rear wall	1	1	1	1	1	1	1	1	1	1
Double Rack middle frame	-	-	-	-	1	1	1	1	1	1
- upper truss structure (removable)	-	-	-	-	1	1	1	1	1	1
- lower truss structure - " -	-	-	-	-	1	1	1	1	1	1
Connector bracket	1	1	1	1	2	2	2	2	2	2
Connector bracket access panel	1	1	1	1	2	2	2	2	2	2
Removable shear load diagonals (maximum)	2	2	2	2	4	4	4	4	4	4
Cable tie struts	12	12	12	12	24	24	24	24	24	24
Center post Z-fittings **	-	-	-	-	22	22	22	22	22	22
Attachment fittings										
Type 1	32	32	32	32	48	48	48	48	48	48
Type 2	24	24	24	24	24	24	24	24	24	24
Type 3	24	24	24	24	24	24	24	24	24	24
Type 4	-	-	-	-	64	64	64	64	64	64
Type 5	-	-	-	-	8	8	8	8	8	8
Type 6	-	-	-	-	8	8	8	8	8	8
RAU Access Panel	1	1	1	1	1	1	1	1	1	1
EPSP Access Panel	1	1	1	1	1	1	1	1	1	1
Thermal Control										
Air duct assembly	1	1	1	1	2	1**	2	2	2	2
Fire suppression system	1	1	1	1	1	1	1	1	1	1
Experiment heat exchanger	-	-	-	-	-	1	-	-	-	-
Experiment cold plate	-	-	-	-	-	1	-	-	-	-
Avionics										
Experiment power switching panel (EPSP)	1	1	1	1	1	1	1	1	1	1
Provisions for Remote Acquis. Unit (RAU)	1	1	1	1	1	1	1	1	1	1
Intercom Remote Station (ICRS)	-	-	-	-	-	1	1	-	-	1

* upper truss structure is an essential structural element which may be removed only temporarily to ease integration activity!

** quantity used for cable tie struts

*** if heat exchanger and/or cold plate are installed

One additional Spacelab supplied mission dependent data display syst. (DDS) can be installed in any standard experiment rack within the experiment envelopes provided

Dimensions see Table 3 - 24 main volume of SPAH

Description see para 4.4.6.3 "

3.2.1.1 Rack Payload Envelopes

The nominal envelopes available for the accommodation of payloads within racks, together with additional space- (subject to rack flight configuration) are given in Figures 3.2 - 5. Variances are due to the necessary installation of mission dependent subsystem equipment, such as EPSP's, RAU's, and the intercom remote stations.

If the RAU is not installed a certain volume still has to be kept clear to allow Subsystem Access to the EPSP as indicated in the drawings. This Subsystem Access volume may be used for easily removable experiment equipment only, e.g. for stowage drawers.

The front protrusion envelopes are determined by operational constraints (floor panels, MGSE) and crew habitability considerations.

The rear space (cross hatched area) is usually taken by the air ducts, the fire suppression lines, subsystem cabling, and experiment utilities attached to the tie struts. If a rack is used completely passive, i.e. without power supply and hence without the need for cooling, fire detection and fire suppression the full cross hatched area is available for payload.

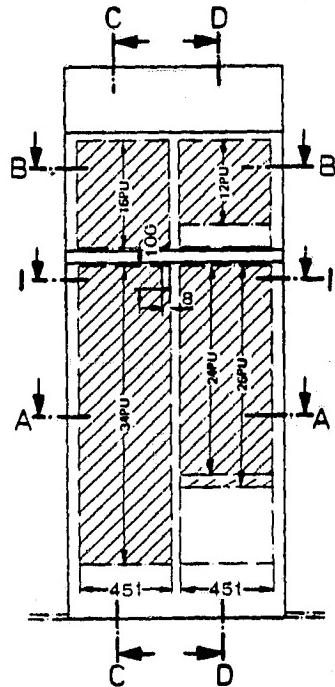
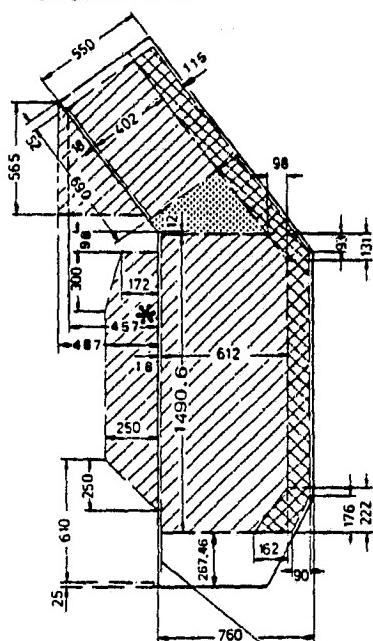
The triangular space at the kink of the rack (dotted area) is also available for experiments. However, because of its shape it cannot be used for 19" slide-in equipment.

The right side of a double rack and a single rack are identical as far as the envelope is concerned. Only some double racks (4, 7, and 10) carry an intercom panel station in addition. The left side of rack 4 is different from the other double racks due to the accommodation of the experiment heat exchanger and cold plate.

The height of front panel area available for experiments is called out in Panel Units (PU). A panel unit (including the maximum tolerance of 0.8 mm per total panel height) is equivalent to the smallest possible panel height in accordance with MIL-STD-189, i.e. $43.65^{+0.8}_{-0} = 44.45$ mm (1 3/4 inch). 44.45 mm (1 3/4 inch) is also the pitch of the mounting pattern of the rack front posts. The details of Figure 3.2 - 7, lower part, apply for all experiment double racks (right sides) and all single racks.

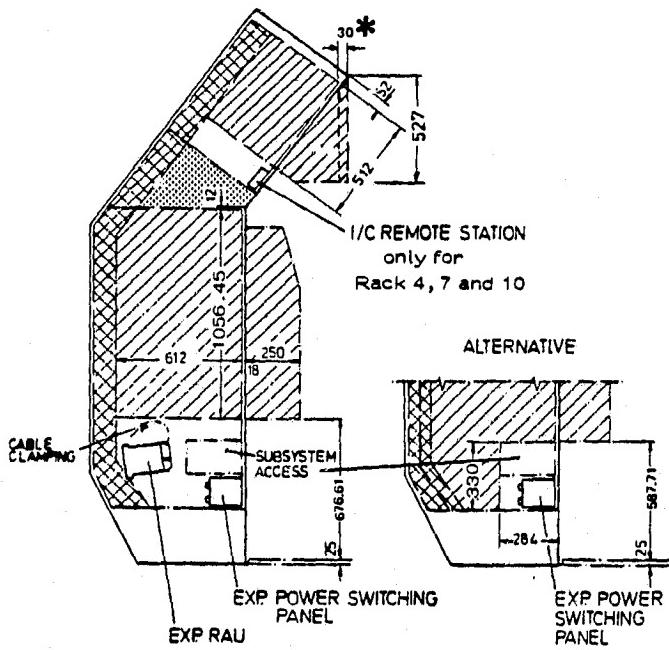
The respective upper and lower rack cross sectional envelopes for both single and double racks are given in Figure 3.2 - 5.

SECTION C-C



Front Panel Mounting Plans

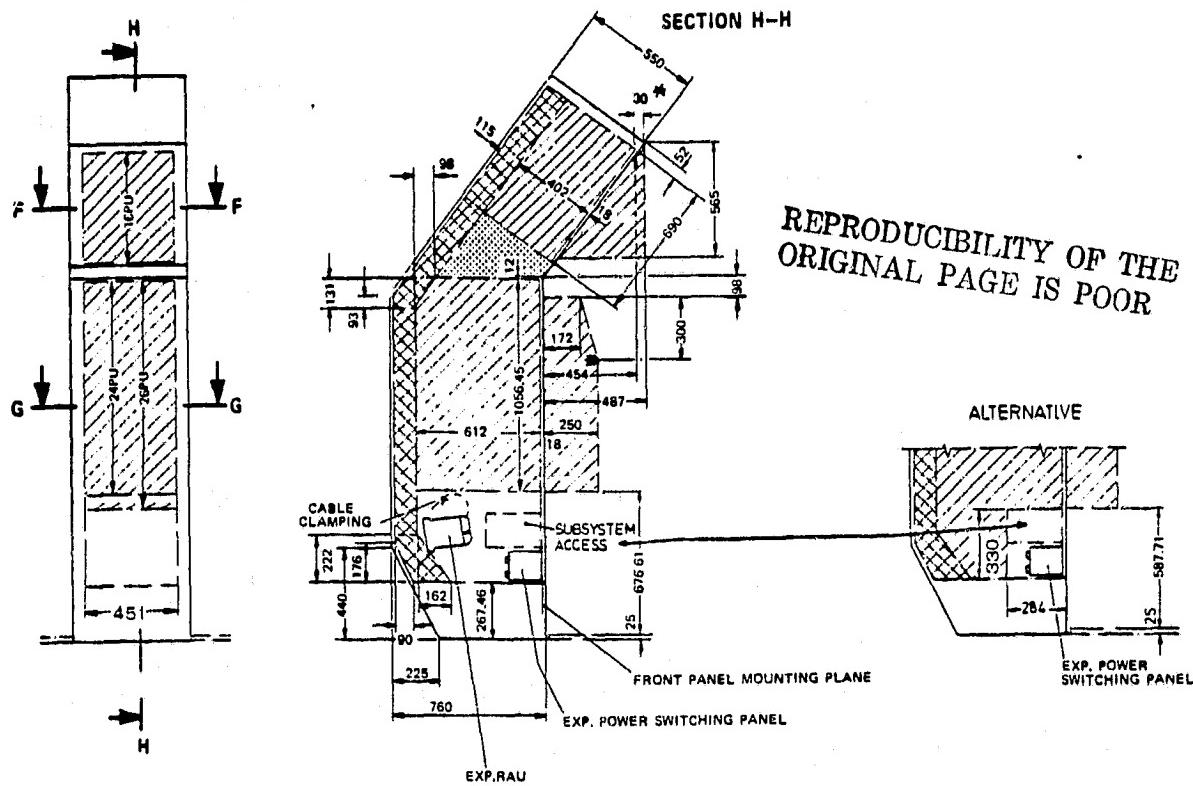
SECTION D-D



Section I-I see also
Fig. 3.2-12b

Explanations see Fig. 3.2 - 5b

Figure 3.2 - 5a: Payload Envelope - Double Rack



Nominal Envelope

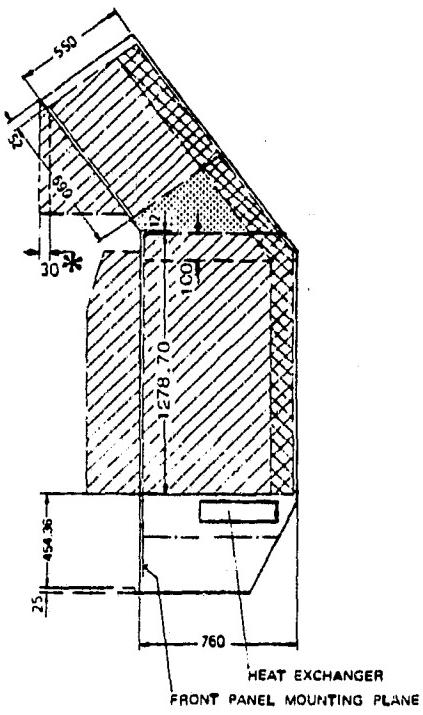
 Envelope of 115 mm available for payload in completely passive stowage racks which do not contain cables, airduct, and fire suppression line.

This space is available for payload but cannot be used for 19" type equipment.

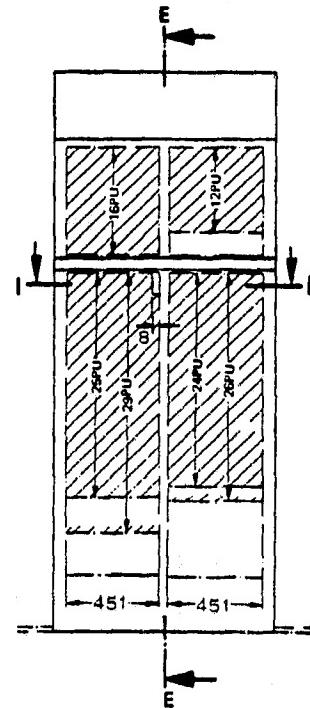
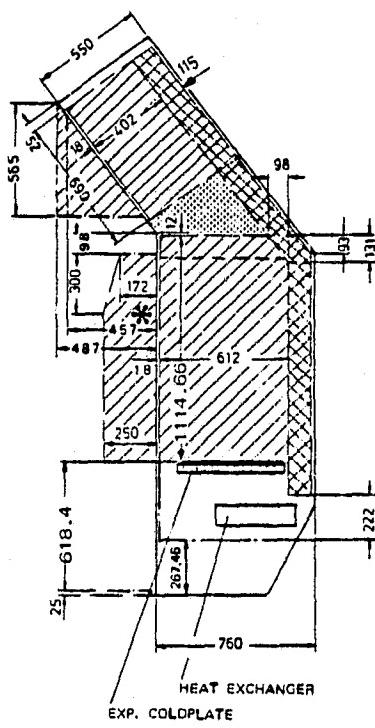
* Reduced Envelopes
when Airlock is flown in order to allow clearance during integration of rack train with the airlock already installed (see also Section 6.2 in the main volume)

Figure 3.2 - 5b: Payload Envelope - Single Rack.

SECTION E-E
ALTERNATIVE



SECTION E-E

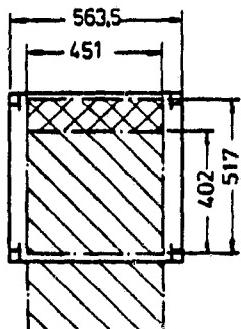


Section I-I see also
Fig. 3.2-12b

Explanations see Fig. 3.2 - 5b

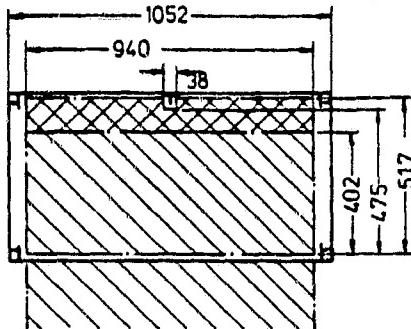
Figure 3.2 - 5c: Payload Envelope - Rack 4

SECTION F-F



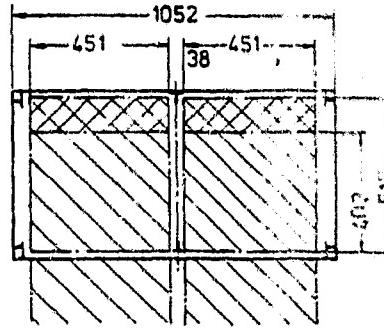
STANDARD SINGLE RACK

SECTION B-B



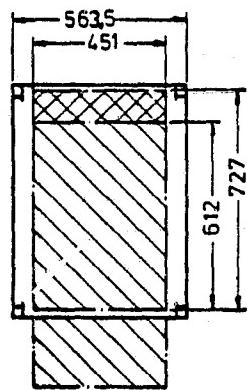
STANDARD DOUBLE RACK
(WITHOUT MIDDLE FRAME)

SECTION B-B

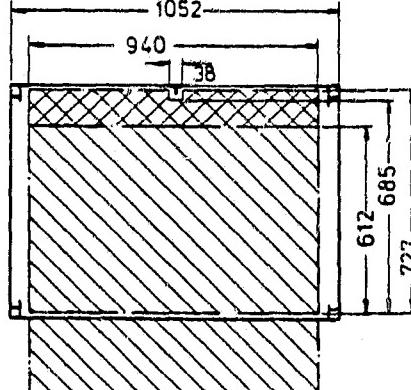


STANDARD DOUBLE RACK

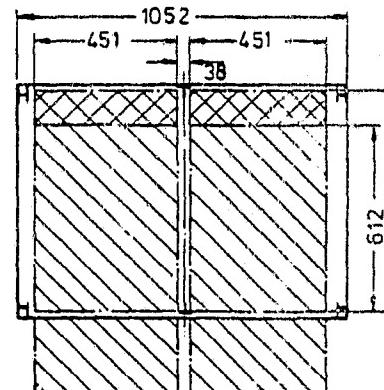
SECTION G-G



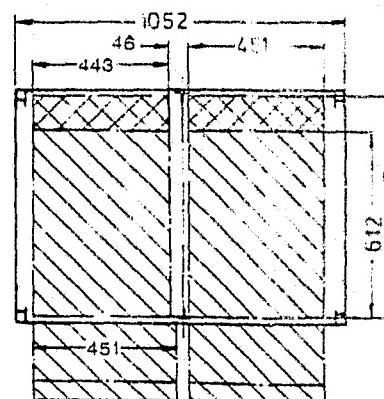
SECTION A-A



SECTION A-A



SECTION I-I



see Fig. 3.2 -5a/b for definition of
cross sections

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Section I-I see also
Fig. 3.2-12b

Figure 3.2 - 5d: Payload Envelopes - Cross Sections

3.2.1.2

Assembly Drawings

Assembly drawings of all experiment racks, showing the installation of mission dependent equipment (MDE) as well as the main dimensions, are given in this section.

Figure 3.2 - 6 shows the Experiment Single Rack 5 (also valid for Rack 6, 11 and 12).

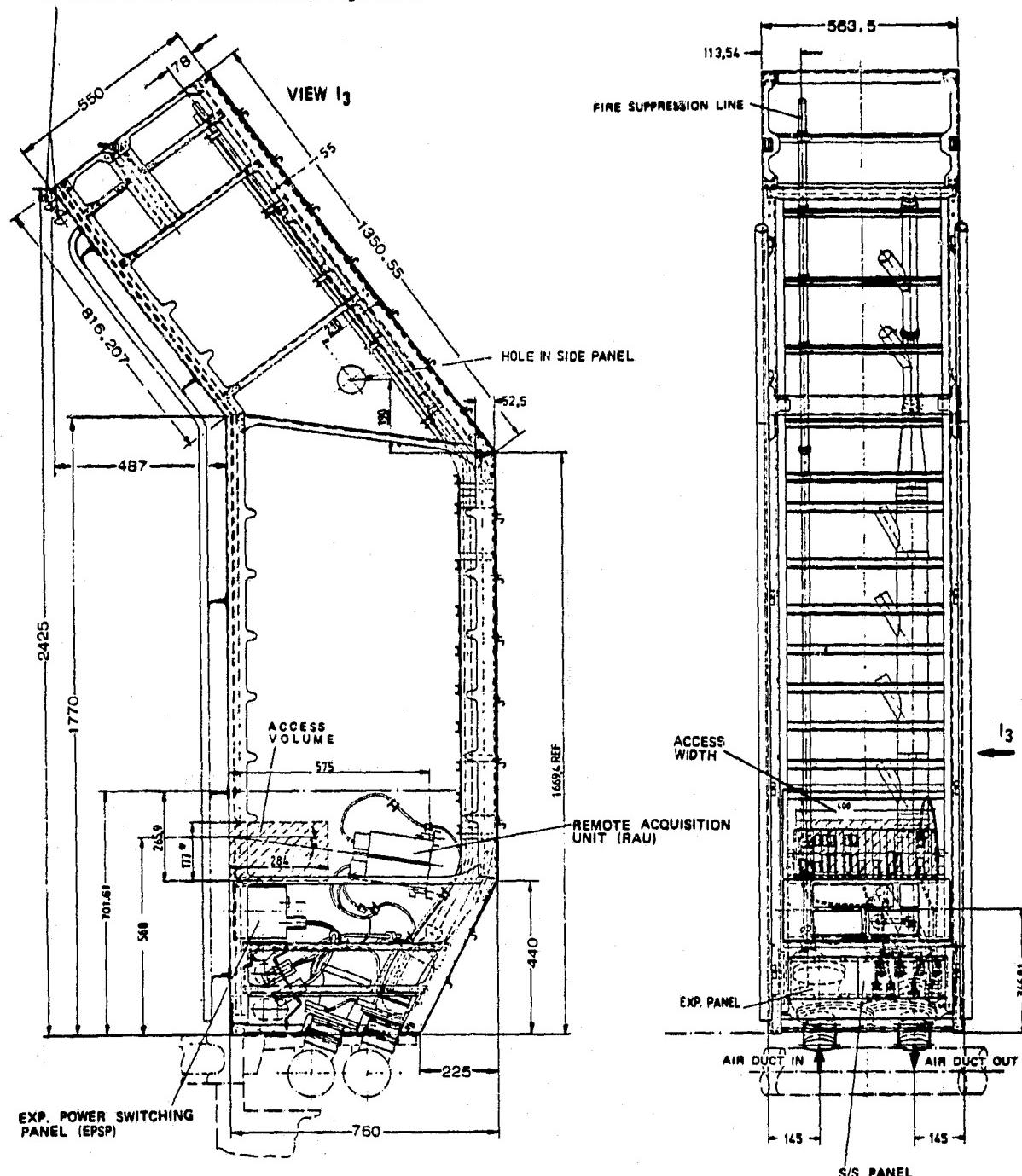
Figure 3.2 - 7 shows Experiment Rack 3 (also valid for Rack 8 and 9) with the Experiment Power Switching Panel (EPSP) and the Remote Acquisition Unit (RAU) installed in the lower part of the right side of the rack. If no RAU is installed, access to the EPSP connectors has to be provided via a free space behind the EPSP access panel (blind panel) which in this case replaces the RAU access panel.

Figure 3.2 - 8 shows the Experiment Double Rack 7 (also valid for Rack 10) where in addition to Racks 3, 8 and 9 an Intercom Remote Station (ICRS) is installed in the right side upper part of the rack.

A special type of an Experiment Rack is represented by Rack 4, adjacent to the Control Center Rack. In addition to the ICRS and mission dependent equipment such as the EPSP and the RAU, a Spacelab provided heat exchanger (HX) and coldplate can be installed in the lower left side of this rack. Figure 3.2 - 9 shows Rack 4 with experiment heat exchanger and coldplate installed.

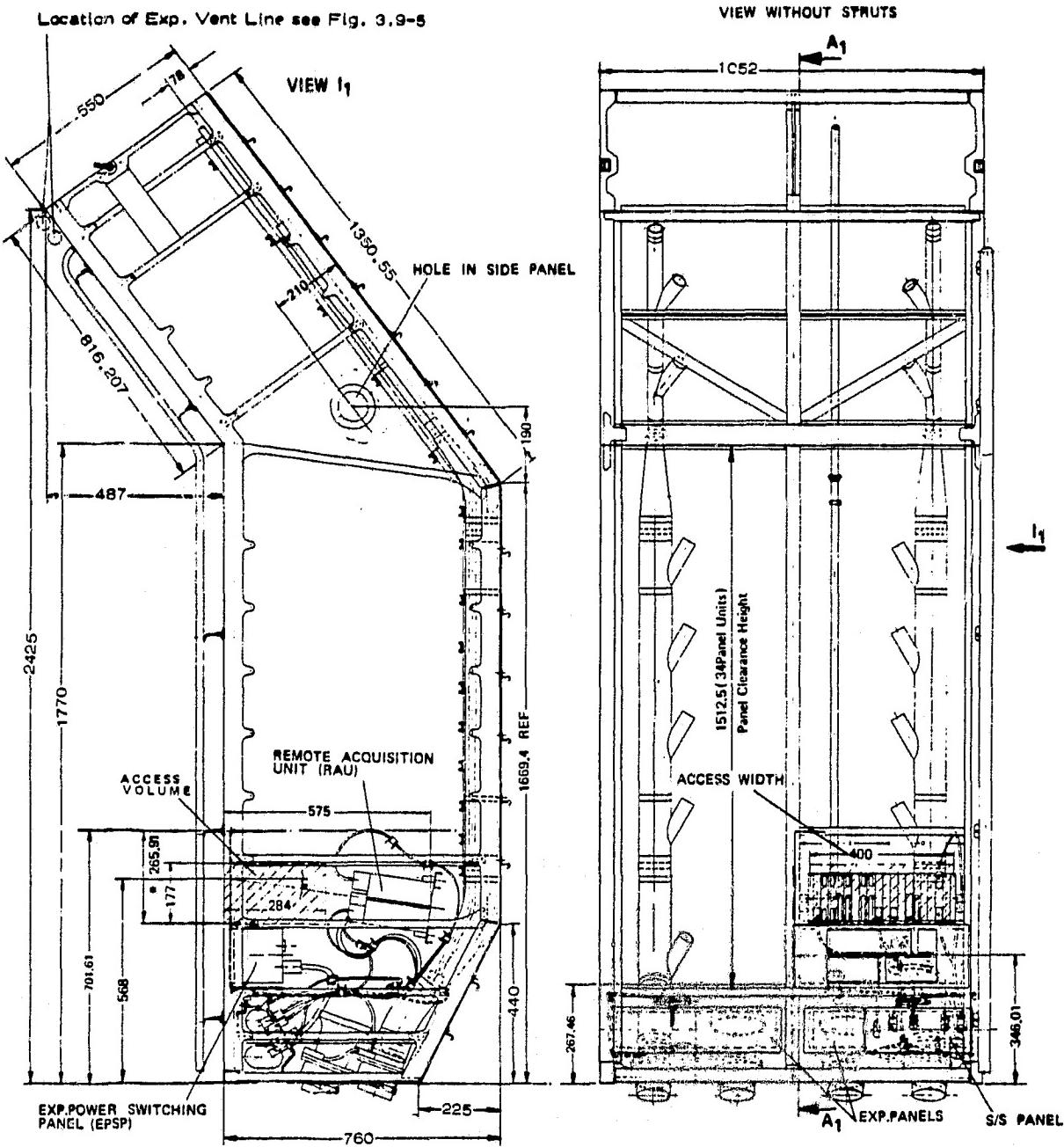
Depending on the Experimenter's requirements, it is possible to install either the heat exchanger and/or the coldplate (see also para 3.2.3.3).

Location of Exp. Vent Line see Fig. 3.9-5



* EPSP access panel 177 mm if no RAU is installed. RAU access panel 265.91 mm.

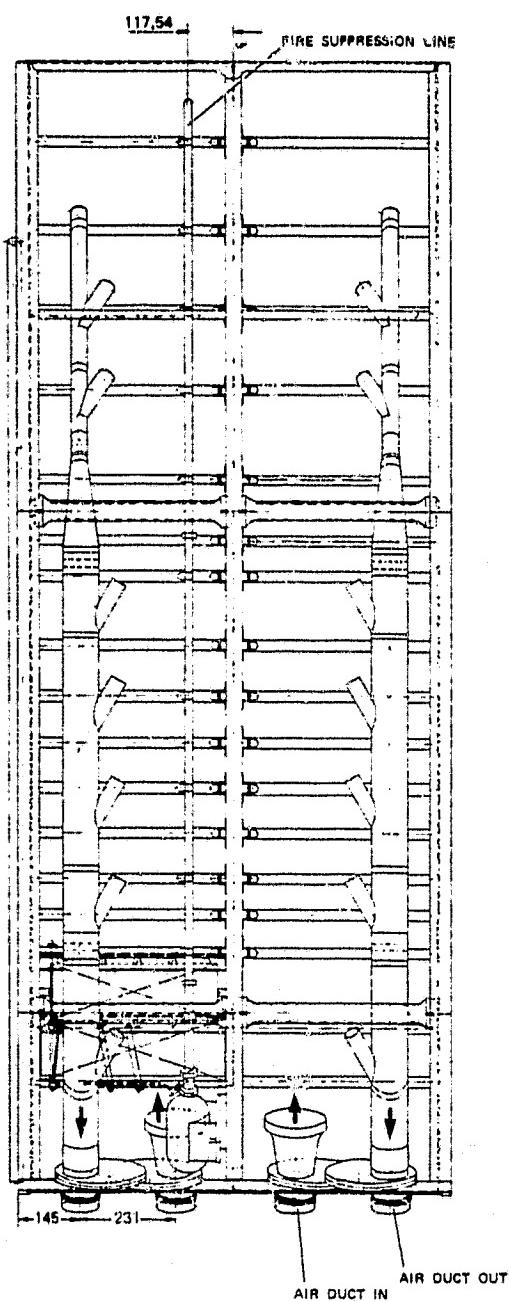
Figure 3.2 - 6 Experiment Single Rack 5 (same for Rack 6, 11 and 12)



* EPSP access panel 177mm if no RAU is installed, RAU access panel 265.91mm

Figure 3.2 - 7a: Experiment Double Rack 3 (same for Rack 8 and 9)

VIEW WITHOUT REMOVABLE REAR PANELS



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SECTION A₁ - A₁

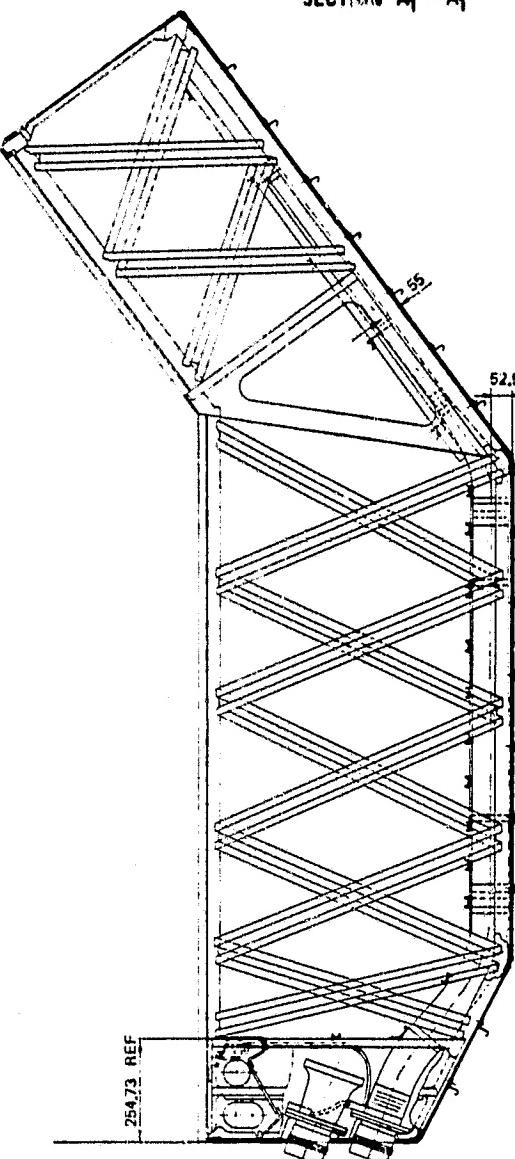


Figure 3.2 - 7 b: Experiment Double Rack 3 (same for Rack 6 and 9)

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Location of Exp. Vent Line see Fig. 3.9-5

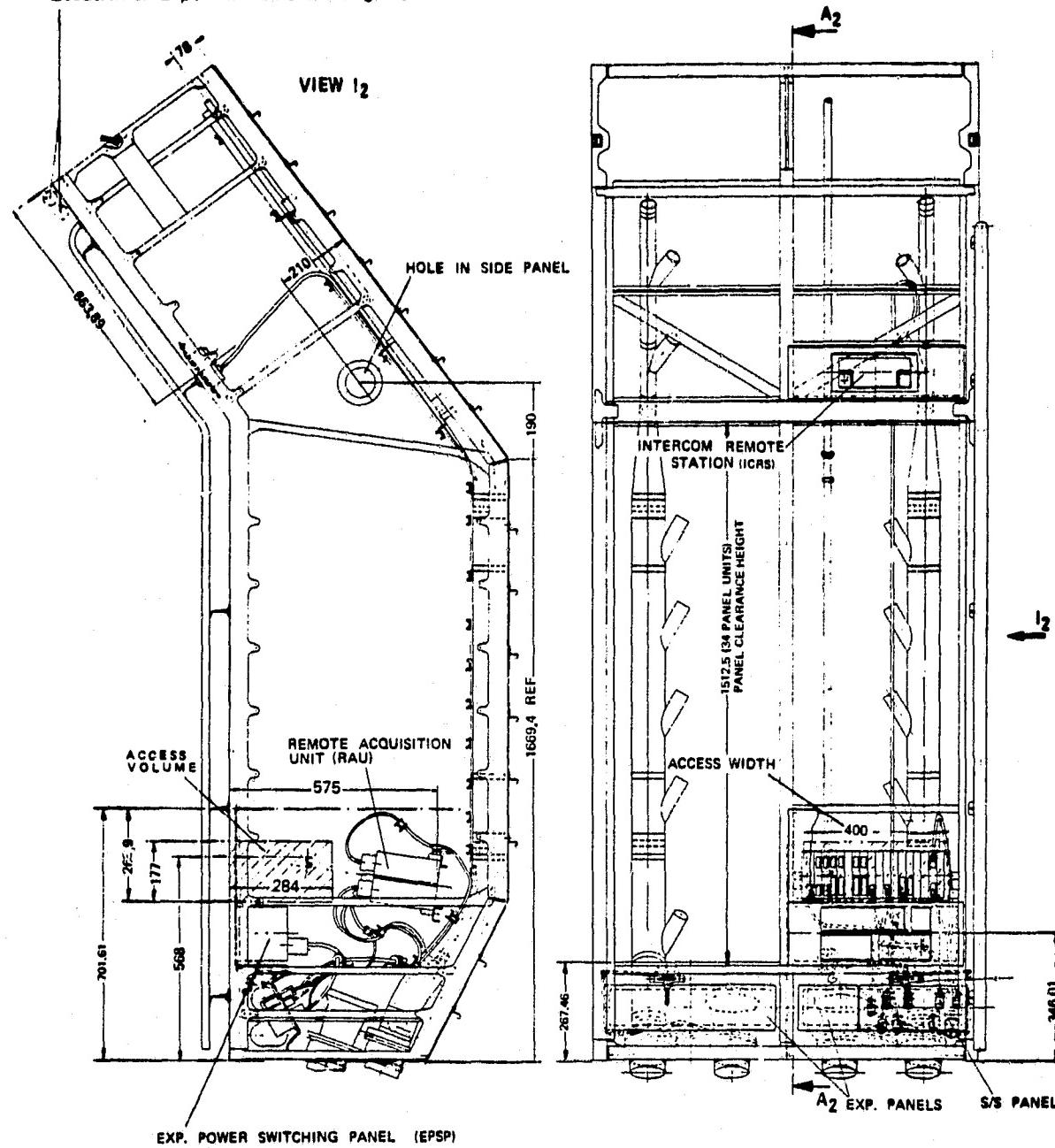
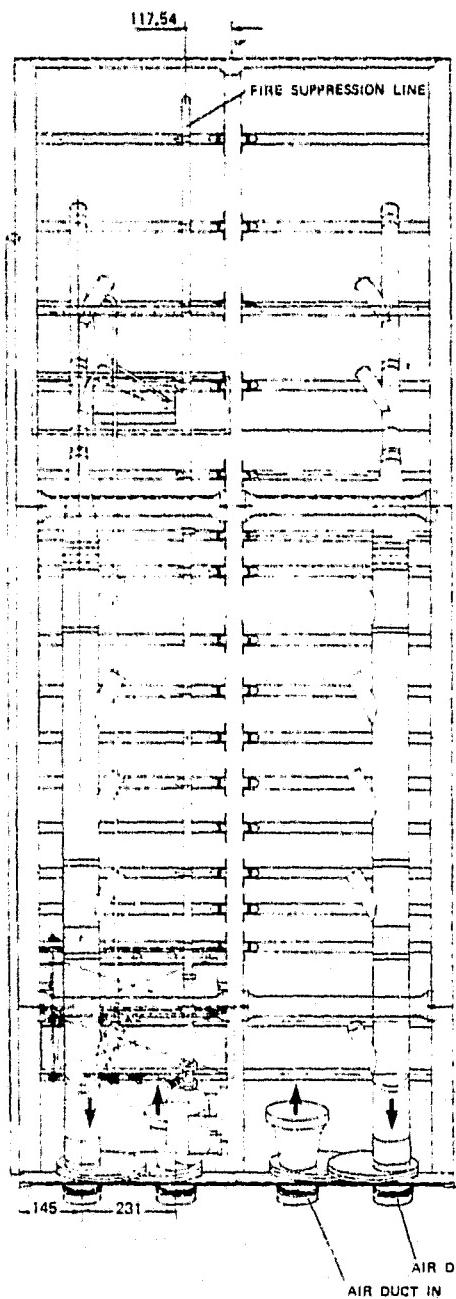
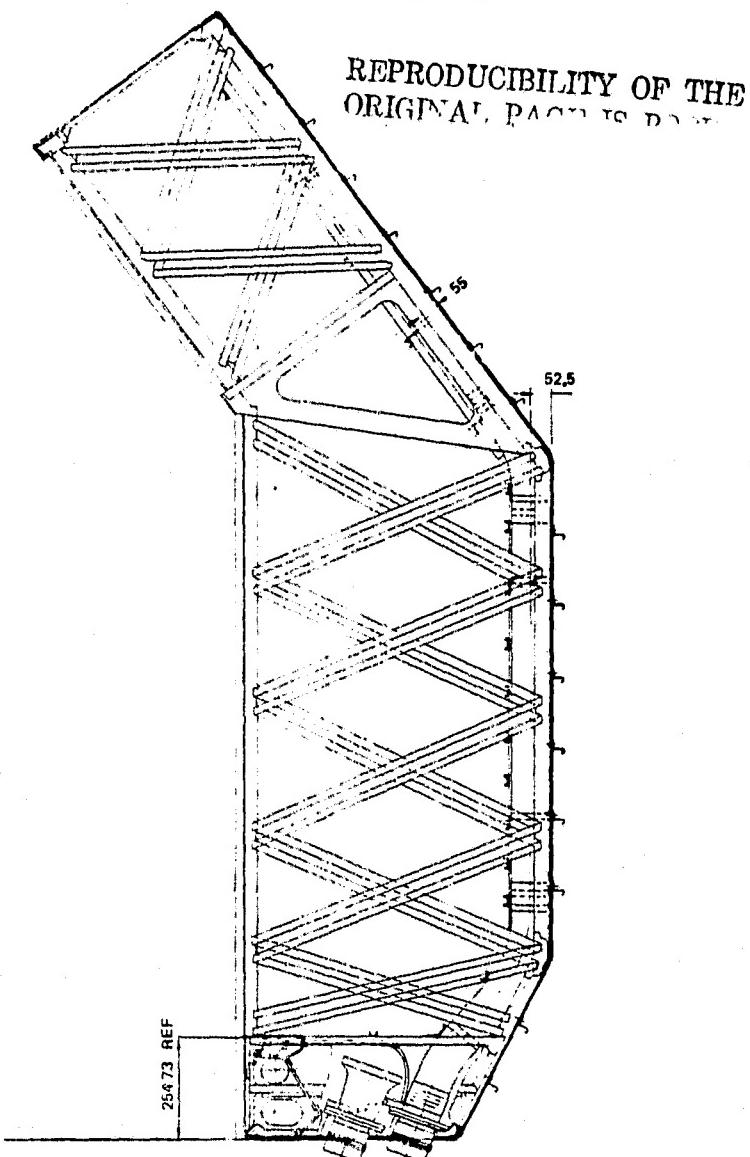


Figure 3.2 - 8a: Experiment Double Rack 7 (same for Rack 10)

VIEW WITHOUT REMOVABLE REAR PANELS



SECTION A₂ - A₂



ALL VIEWS WITHOUT SIDE PANELS
AND LOWER FRONT PANELS

Figure 3.2 - 8b: Experiment Double Rack 7 (same for Rack 10)

Location of Exp. Vent Line see Fig. 3.9-5

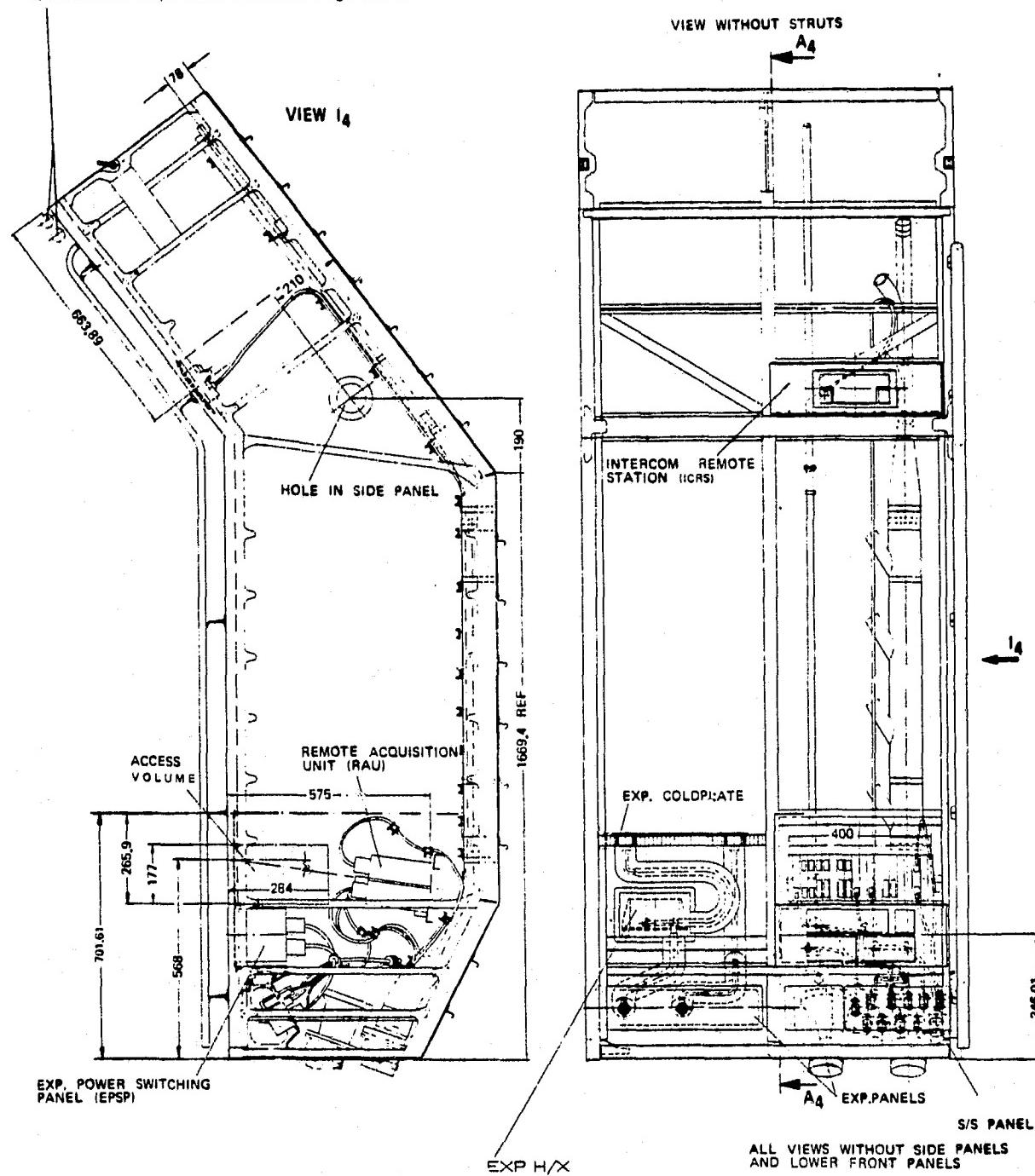
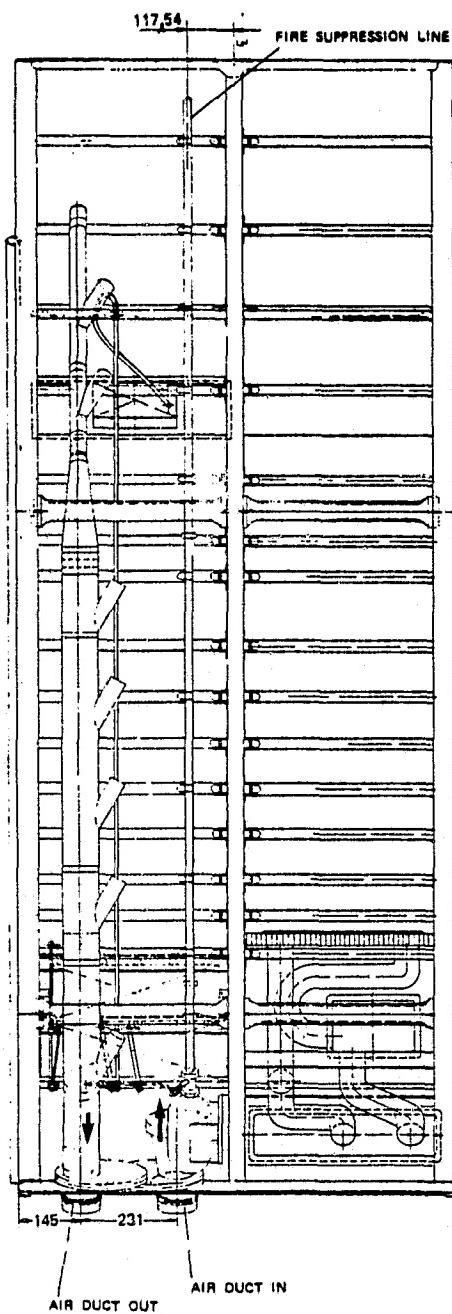
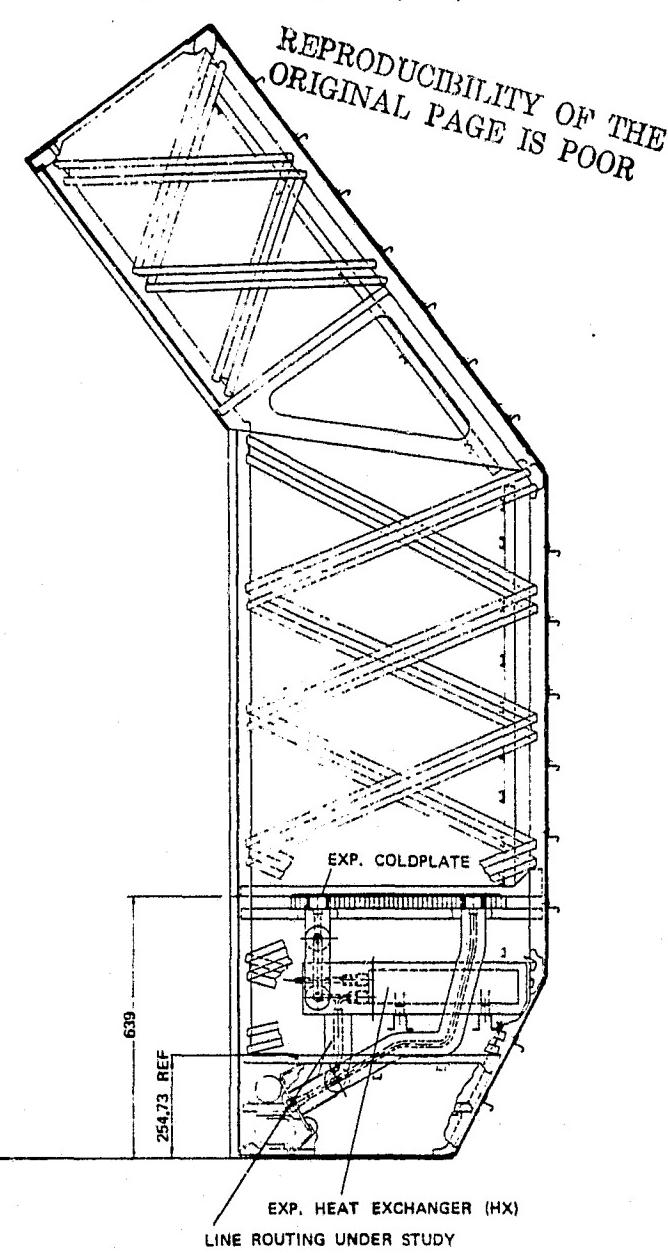


Figure 3.2 - 9a: Experiment Double Rack 4 (Experiment HX and Cold Plate installed)

VIEW WITHOUT REMOVABLE REAR PANEL

SECTION A₄ - A₄Figure 3.2 - 9b: Experiment Double Rack 4(Experiment HX and Cold Plate
(installed))

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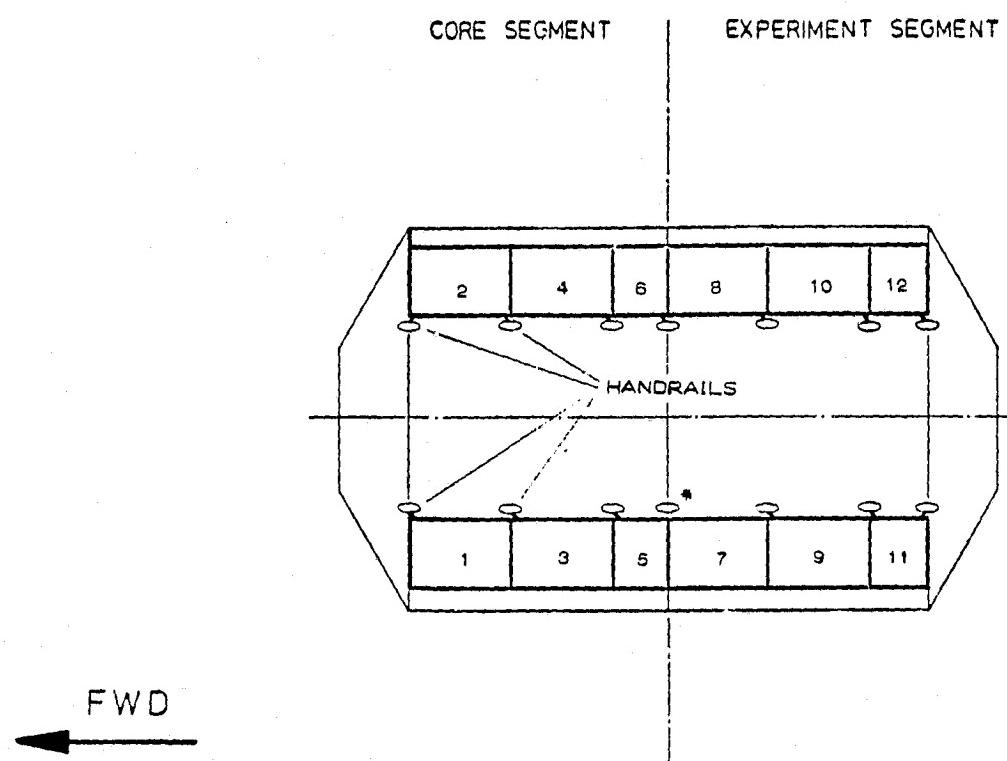
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3.2.1.3 Handrails

The geometry of the handrails for both single and double racks is identical; their respective locations and the cross sectional detail of the handrail is given in Figure 3.2 - 11.

The handrails provide the possibility to accommodate equipment via user provided clamps in compliance with the payload envelope protrusion shown in Figure 3.2 - 5.

The allowable load for the handrails is limited to a local load of 588.6 N per rail. 588.6 N is also the total load per rail.



* Short Module - mounted at Single Rack 5
Long Module - mounted at Double Rack 7

Figure 3.2 - 10: Location of Handrails

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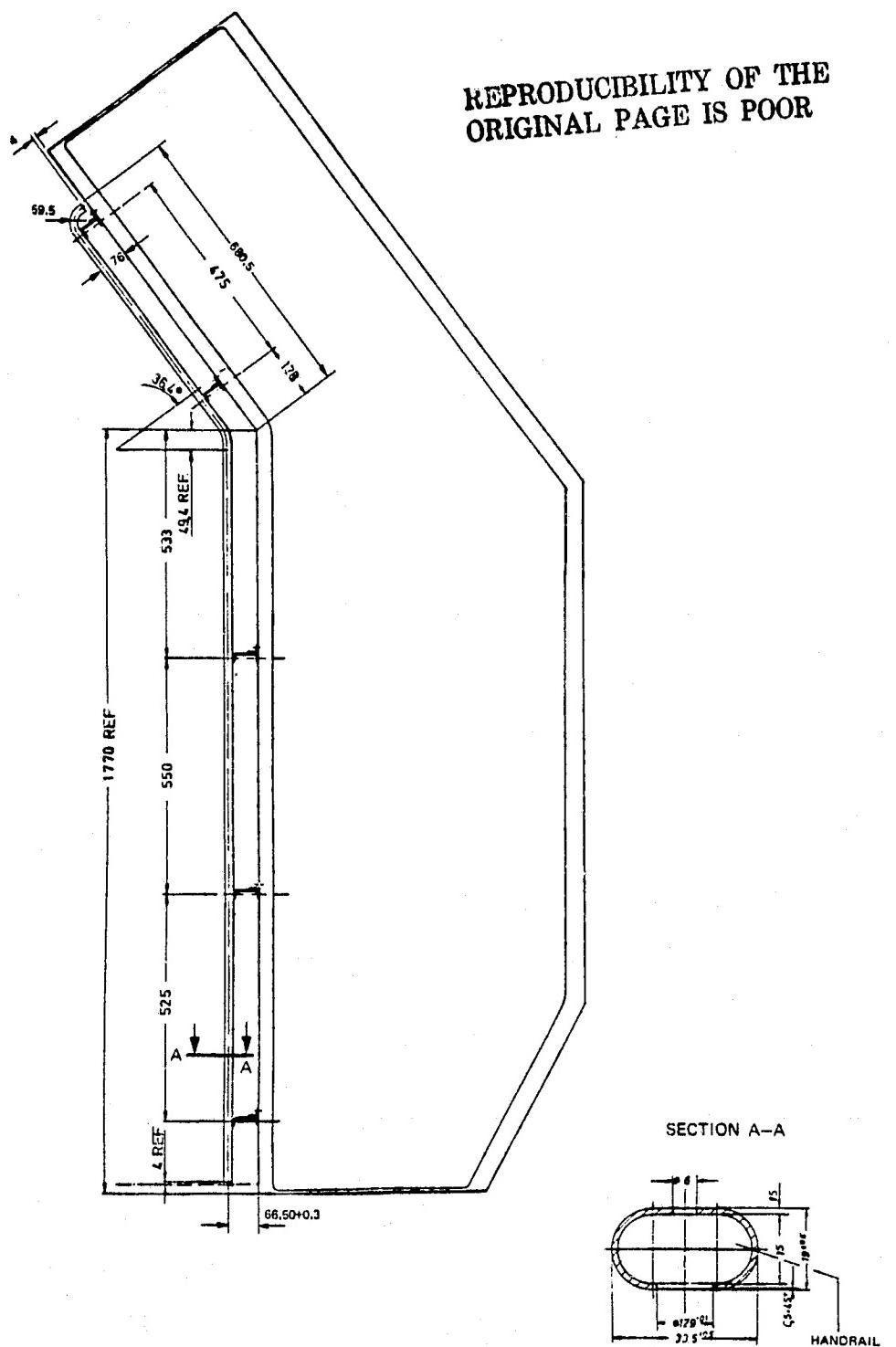


Figure 3.2 - 11: Handrail

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3.2.2 Structure Interface

The rack structure is designed for standard 19" equipment. Mounting of Payload equipment may be accomplished by means of front panels (according to MIL-STD-189) and user provided internal support structure such as shelving, runners, rails etc.

The front panels will be mounted to the front attachment holes. User provided support structure can be mounted to side attachment holes on rear and front rack posts. The actual accommodation of experiment equipment also has to take into account how the particular rack is staged with subsystems, and rack structural elements like cable tie struts, shear load strut, and middle frame.

3.2.2.1 Standard 19" Equipment

The Spacelab experiment racks are designed for standard 19" equipment as defined in MIL-STD-189. Its main characteristics as well as Spacelab peculiar modifications of this standard are summarized in this section.

3.2.2.1.1 Panel Size

PU (PANEL UNIT)	PANEL SIZES								MIL-STD TYPE
	A	B	C	D	E	F	G	H	
1	43,65	31,75							AC
2	88,10	76,20							BC
3	132,55	57,15							CC
4	177,00	101,60							DC
5	221,45	44,45	57,15	44,45					EC
6	265,91	57,15	76,20	57,15					FC
7	310,36	44,45	146,05	44,45					GC
8	354,80	88,90	101,60	88,90					HC
9	399,25	88,90	146,05	88,90					JC
10	44,45	88,90	190,50	88,90					KC
11	488,16	133,35	146,05	133,35					LC
12	532,61	44,45	133,35	101,60	133,35	44,45			MC
13	577,06	133,35	44,45	146,05	44,45	133,35			NC
14	622,30	44,45	133,35	190,50	133,35	44,45			PC
15	665,96	44,45	177,80	146,05	177,80	44,45			RC
16	710,41	44,45	133,35	88,90	101,60	88,90	133,35	44,45	SC
17	754,85	44,45	133,35	88,90	146,05	88,90	133,35	44,45	TC
18	800,10	44,45	133,35	88,90	190,50	88,90	133,35	44,45	UC

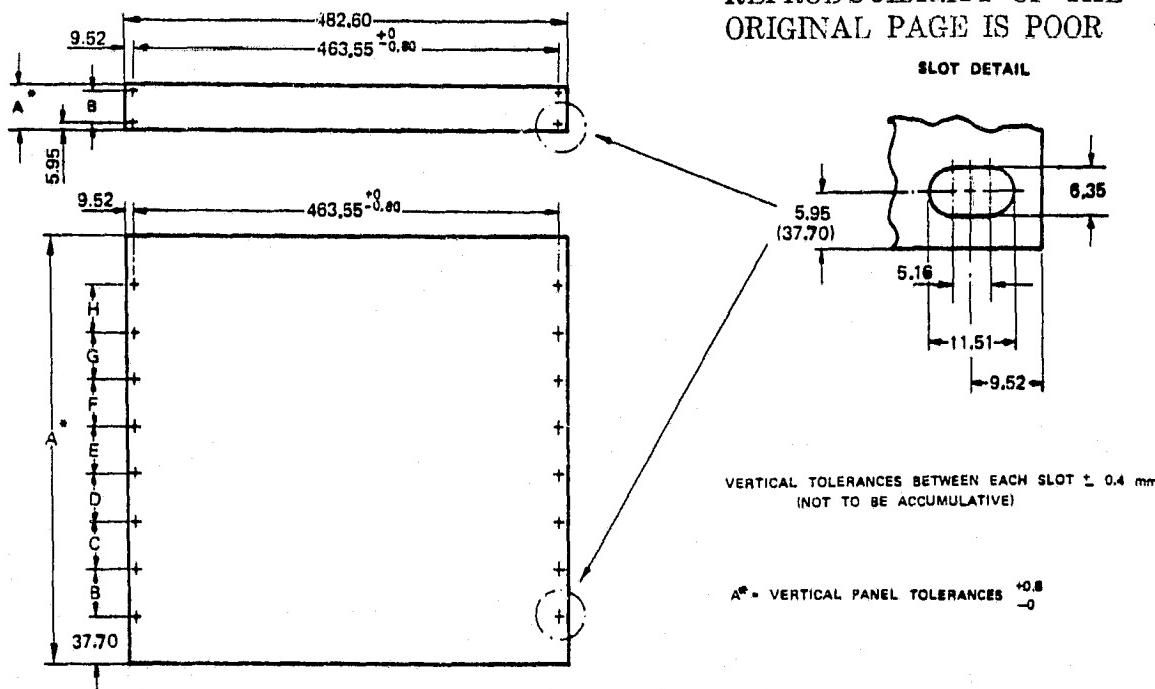
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Figure 3.2 - 12a : Panel Dimension (mm) MIL - STD - 189

For the front panels closed slots according to MIL-STD-189 shall be used. For statically determined mounting one of these holes shall be a close tolerance hole (see also section 3.2.6). These close tolerance holes shall be as near as possible to a stiffened part of the rack or of a diagonal strut.

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3.2.2.1.2 Box Size

The box width is defined in Fig. 3.2-12b. However, the box height, i.e. the recess of the box behind the panel depends on the actual location in the rack.

- * - normally the recess is $\geq 4.6 \text{ mm}$ $^{+0.4}_{-0}$
- at the end of the rack opening (lower as well as upper part) the recess is $\geq 12 \text{ mm}$
- at diagonal shear load struts where a front panel shall overlap half the strut clearance the recess is $\geq 20 \text{ mm}$.

* * see Fig. 3.2-5a and 3.2-5d, Section I-I

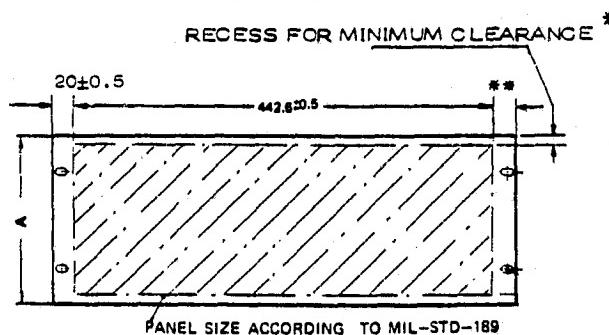


Figure 3.2 - 12b: Equipment Clearances

3.2.2.2 Experiment Attachment Provisions

Front panel mounting is to the front attachment holes having a pitch of $31.75\text{ mm} + 12.70\text{ mm} = 44.45\text{ mm}$ (1 3/4"). For these holes Spacelab provides various attachment fittings with captive nuts for user provided M 5 bolts.

Experiment support structure is mounted to the side attachment holes on rear and front posts by means of user provided M 5 bolts and nuts. The side attachment holes have a pitch of 22.225 mm. Due to interference with the stiffeners of the sidewalls, some lateral holes may not be accessible for experiment installation. Details are TBD.

For side attachment to the middle frame Spacelab provides Z - profile brackets which provide the necessary clearance from the middle frame truss structure.

- * Note : Dimensions apply to all panel mounting holes. Vertical tolerance is $\pm 0.2\text{ mm}$ between any two mounting holes. (Tolerances not to be cumulative!)

3.2.2.2.1 Front Attachment

Developed View on Front Side

Note:
Vertical tolerances between
any two mounting holes
 ± 0.2 mm (not to be
accumulative).

Section A-A / B-B
see Fig. 3.2-13d

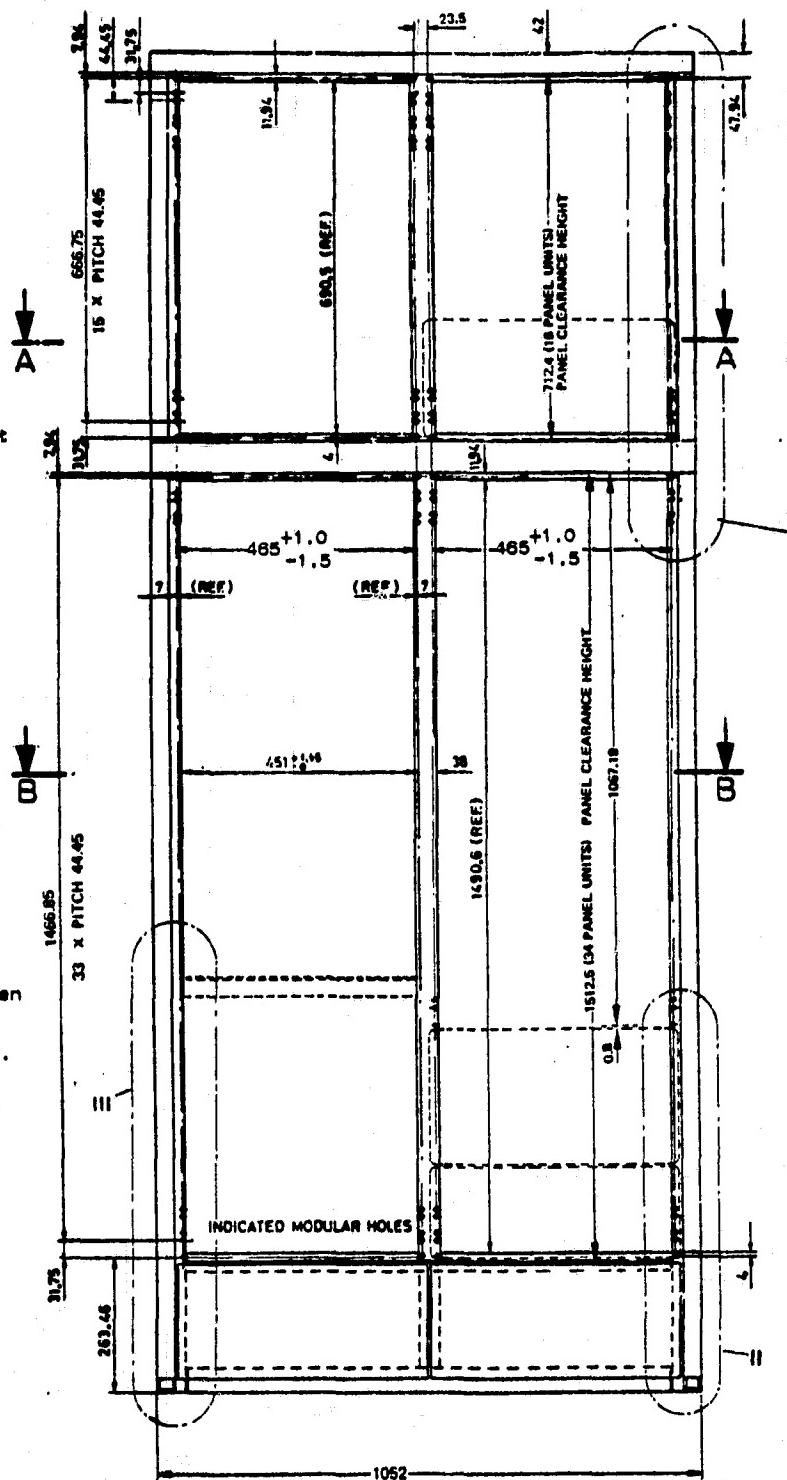
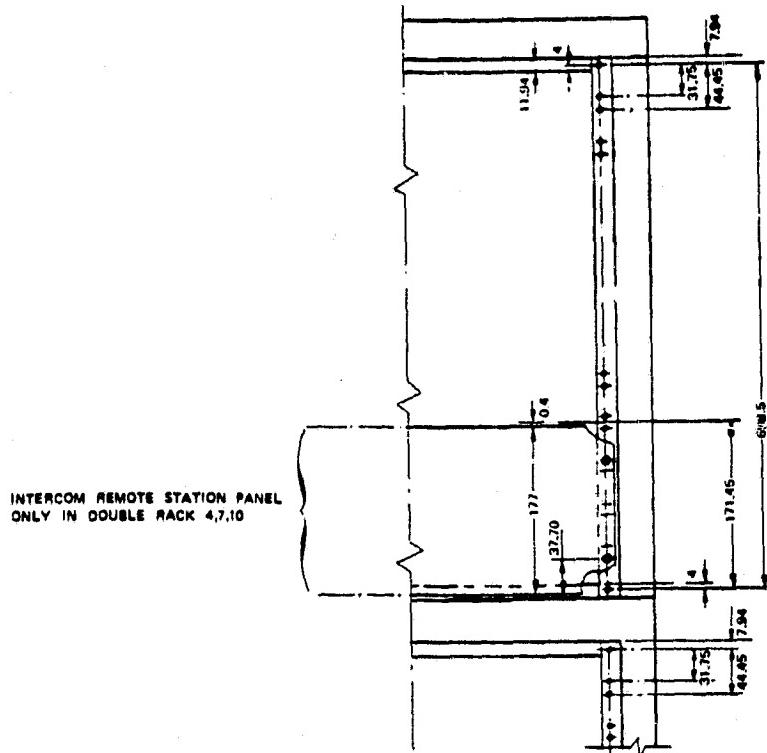


Figure 3.2 - 13a: Front Attachments - Double Rack

DETAIL I



DETAIL II

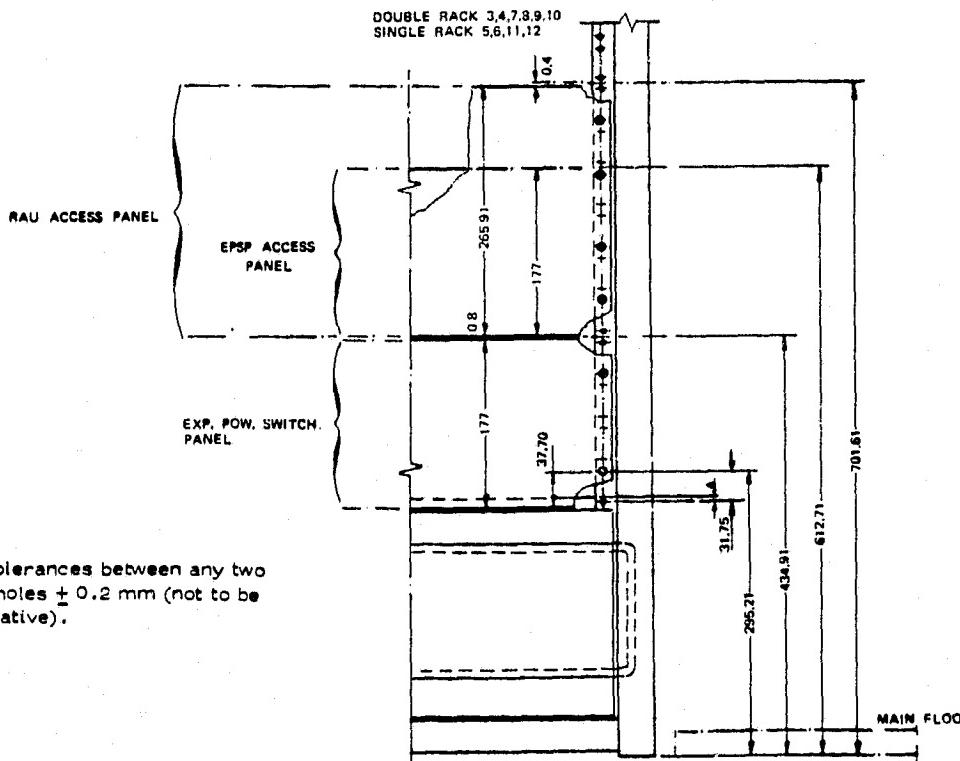
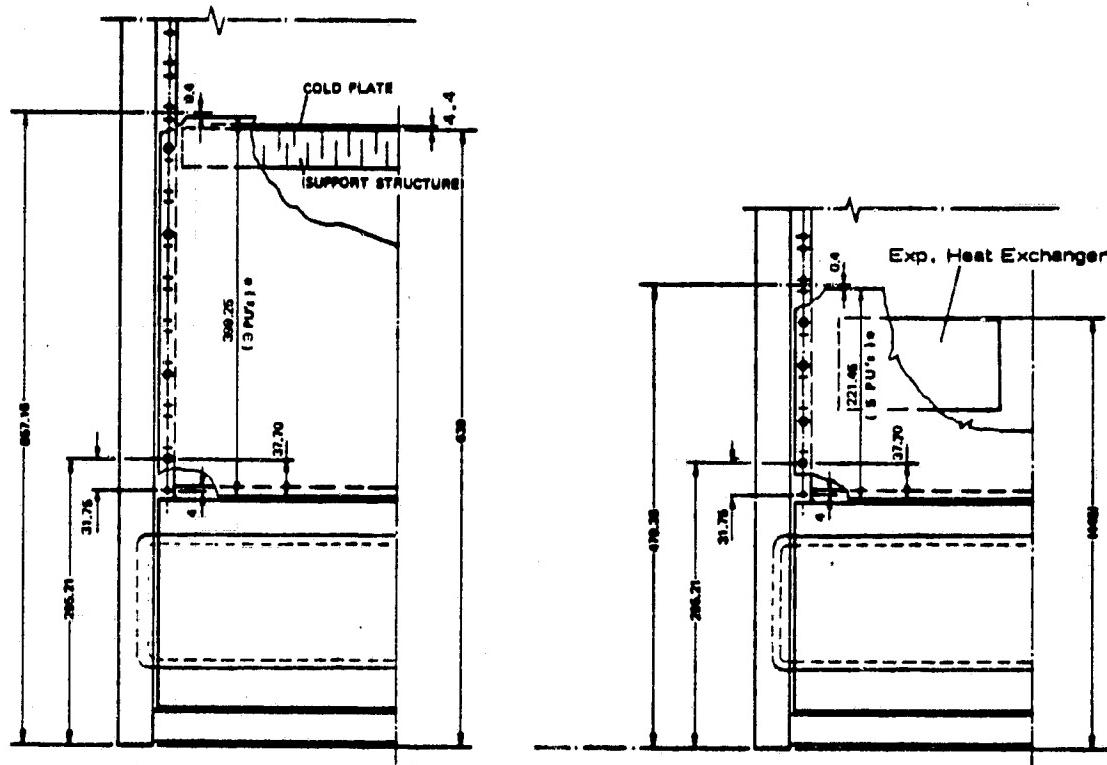


Figure 3.2 - 13 b : Attachment Details Mounting Pattern

DETAIL III



PANEL UNITY

Note: Vertical tolerances between any two mounting holes
± 0.2 mm (not to be accumulative).

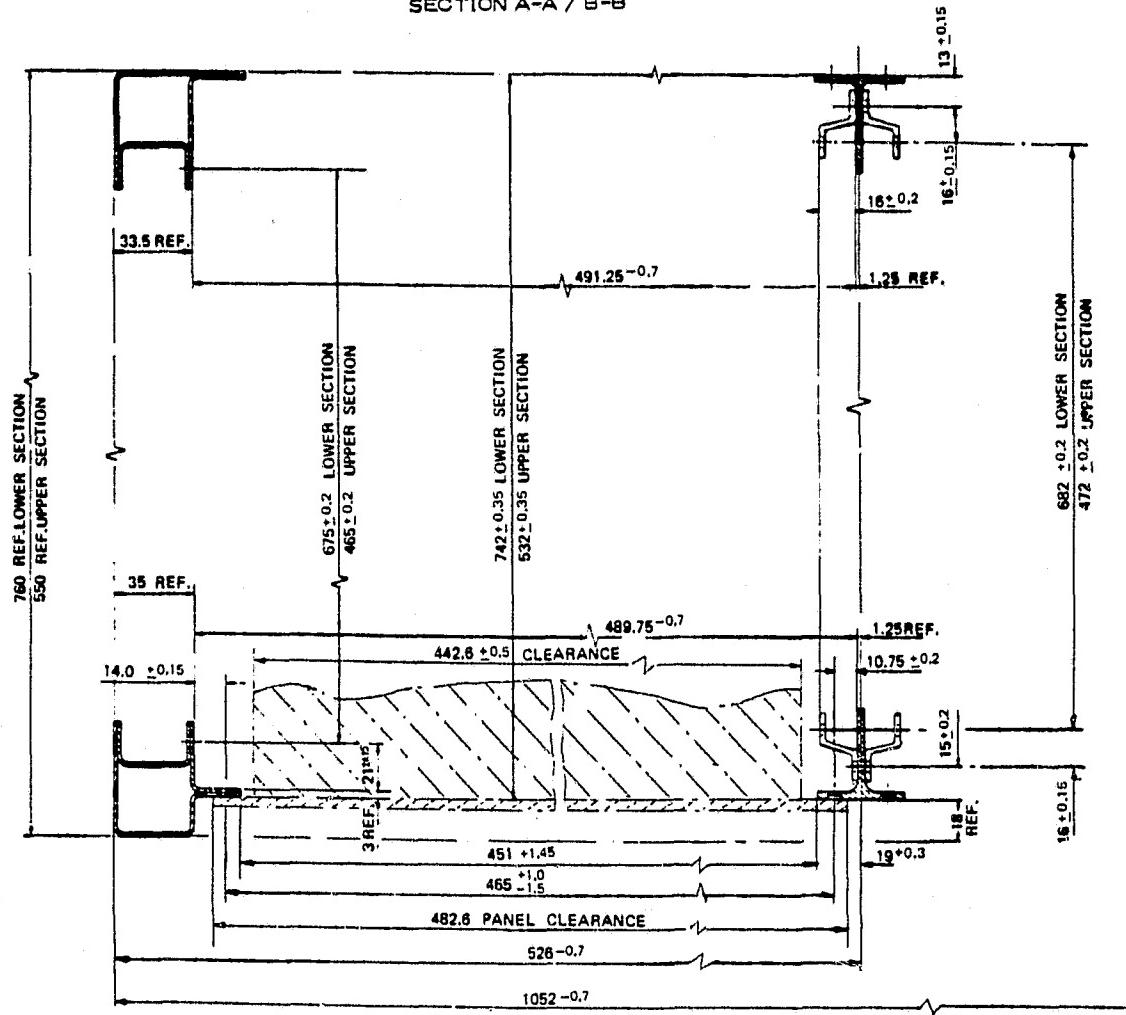
Figure 3.2 - 13c : Details of Panel Clearances, Rack 4

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SECTION A-A / B-B



MODULAR HOLE PATTERN
HOLES #5.2^{.001}

Figure 3.2 - 13d: Cross Sections - Double Rack Left Side

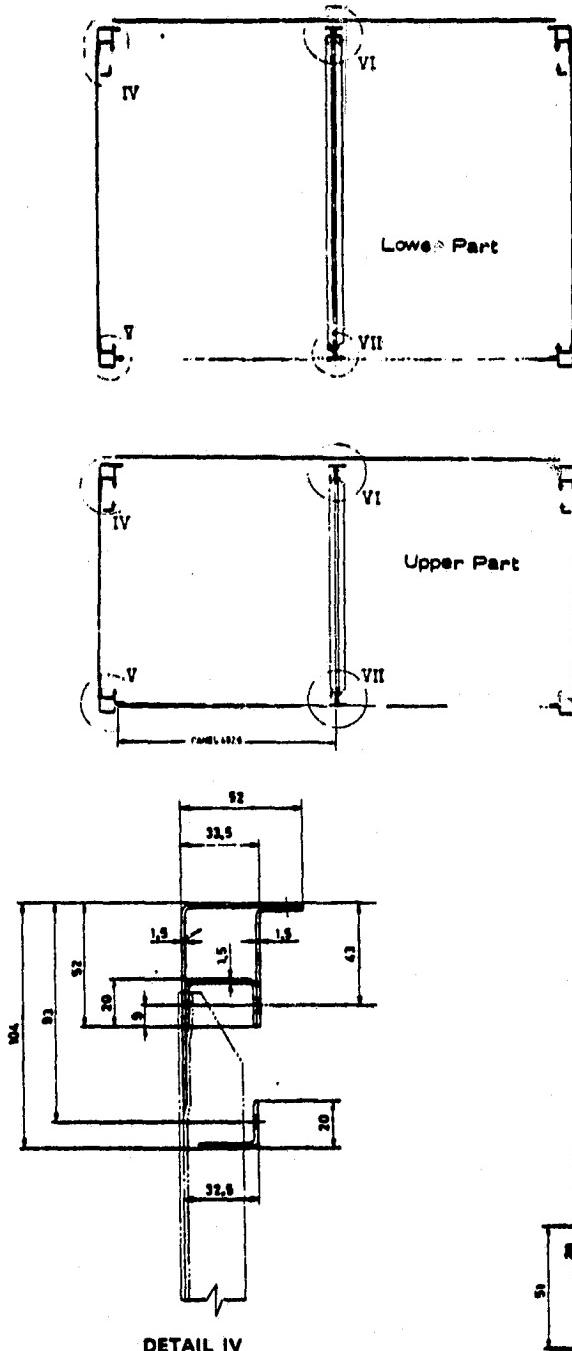


Figure 3.2 - 13e: Cross Sections - Details

B 3.2 - 30

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Developed View on Front Side

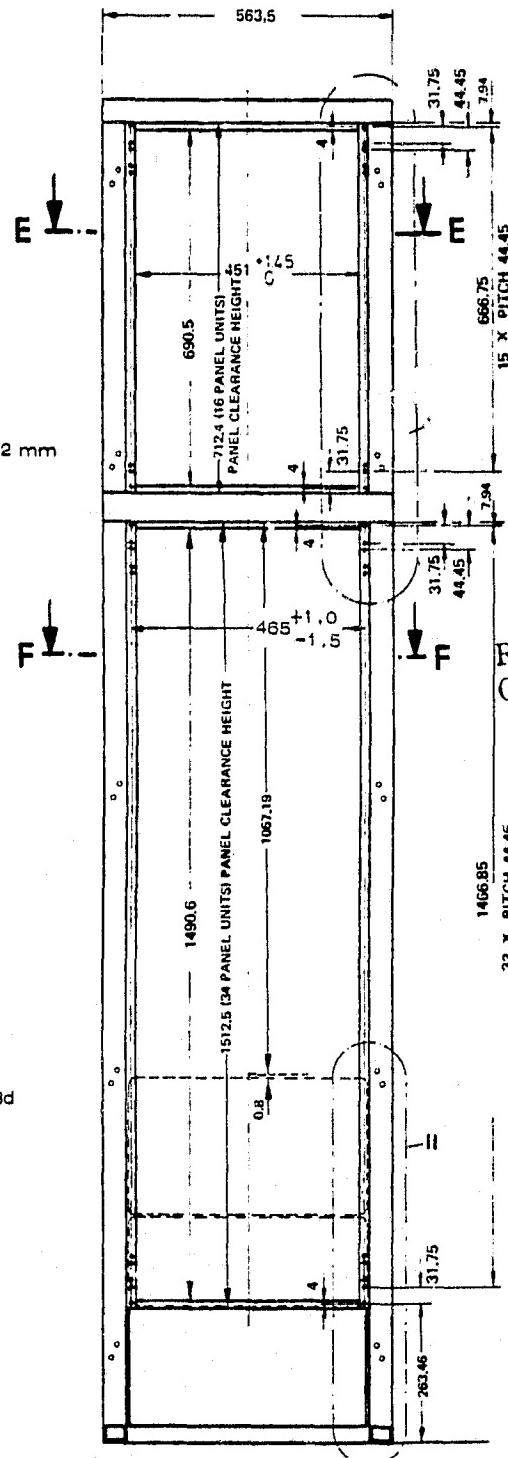


Figure 3.2 - 13f: Front Attachment - Single Rack

SECTION E-E

MODULAR HOLE PATTERN
(HOLES $\# 5.2 \frac{1}{8}$ "ⁱⁿ)

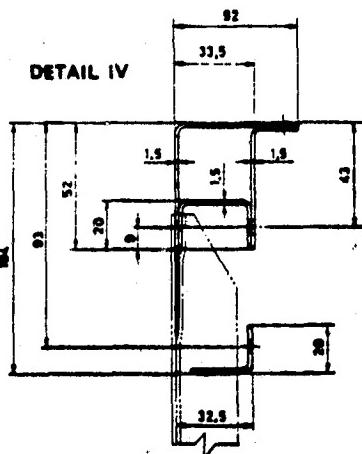
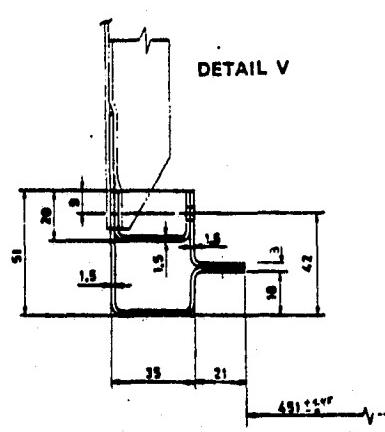
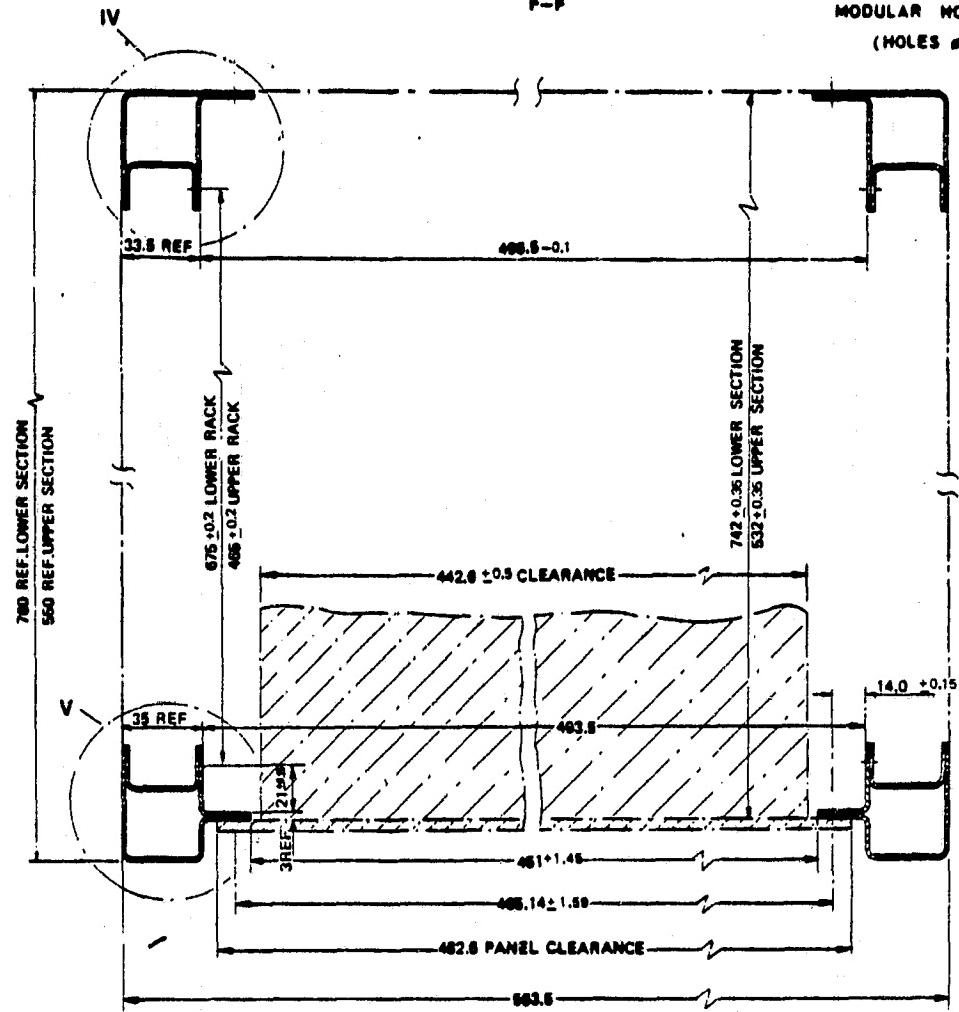
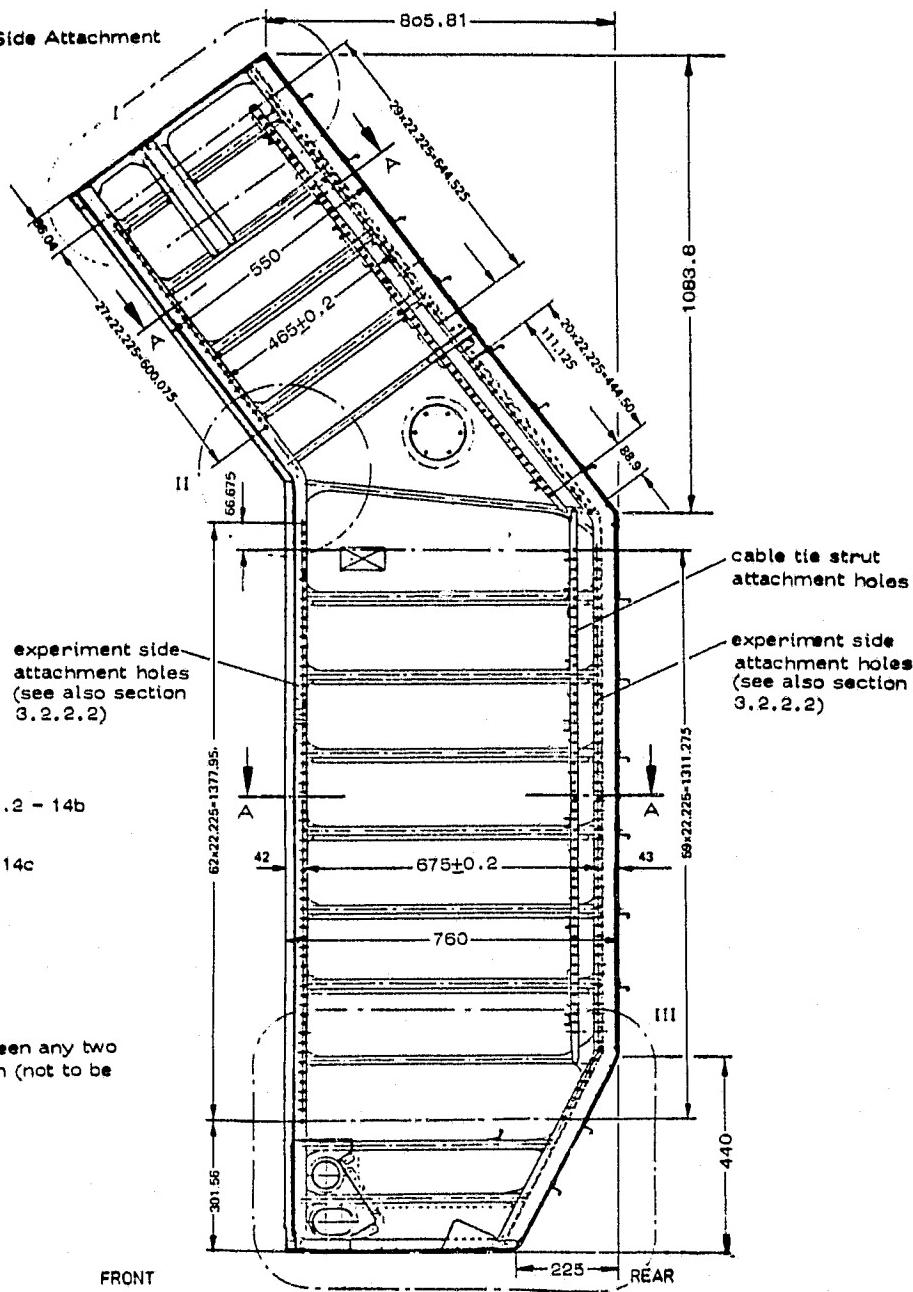


Figure 3.2 - 13g: Cross Sections - Details

3.2.2.2.2

Side Attachment



Detail I and II see Fig. 3.2 - 14b

Detail III see Fig. 3.2 - 14c

Note:

Vertical tolerances between any two mounting holes ± 0.2 mm (not to be accumulative).

Sections A - A

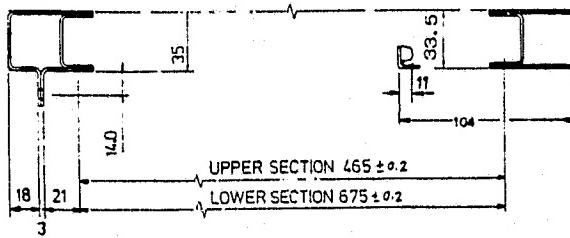
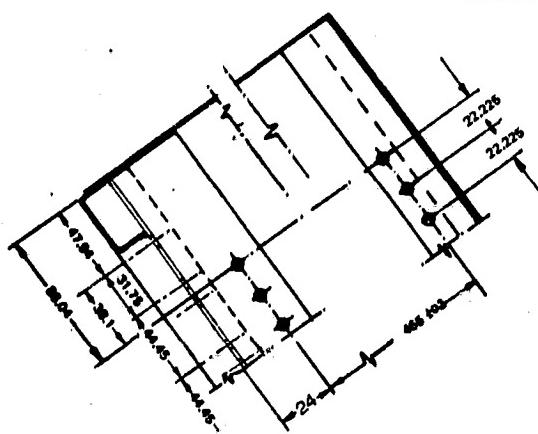


Figure 3.2 - 14a: Side Attachment - Outer Walls

DETAIL I



Note : Tolerances between any two mounting holes ± 0.2 mm
(not to be accumulative).

DETAIL II

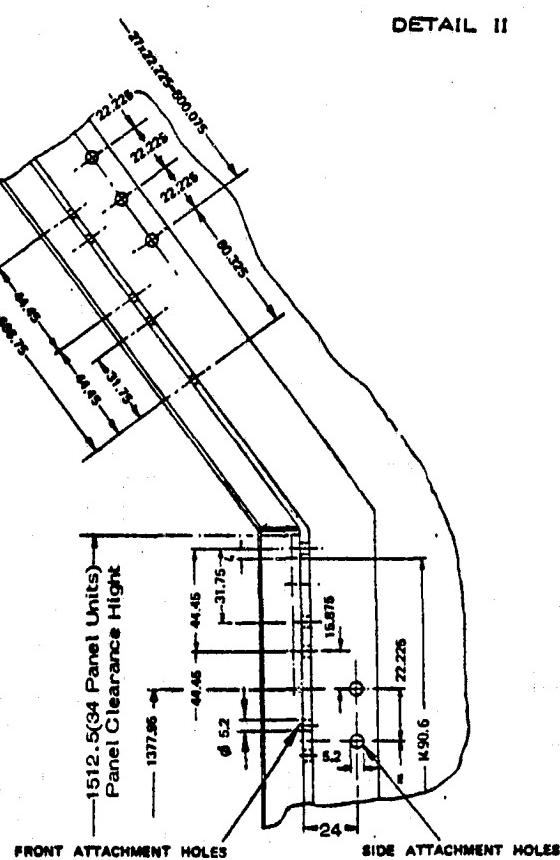


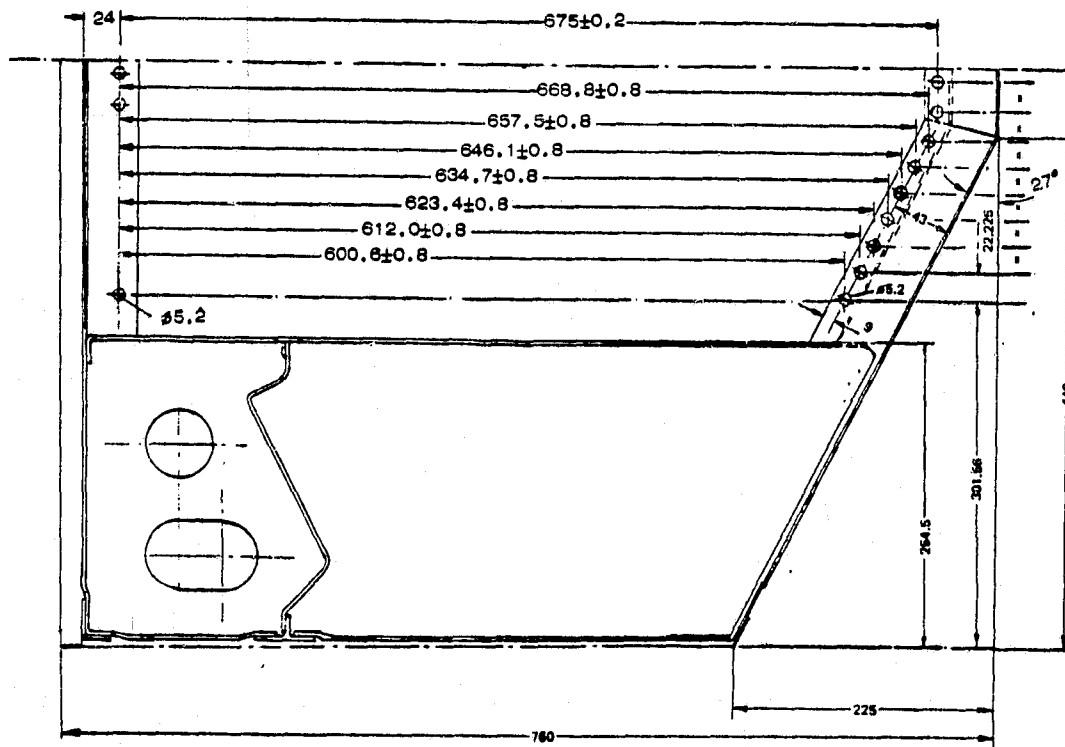
Figure 3.2 - 14 b Side Attachment - Details

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DETAIL III see Fig. 3.2 - 14a



Note: Vertical tolerances between any two mounting holes
 ± 0.2 mm (not to be accumulative).

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Figure 3.2 - 14 c : Detail Interface (Side Post)

Note:
Vertical tolerances between any two mounting holes,
 ± 0.2 mm (not to be accumulative).

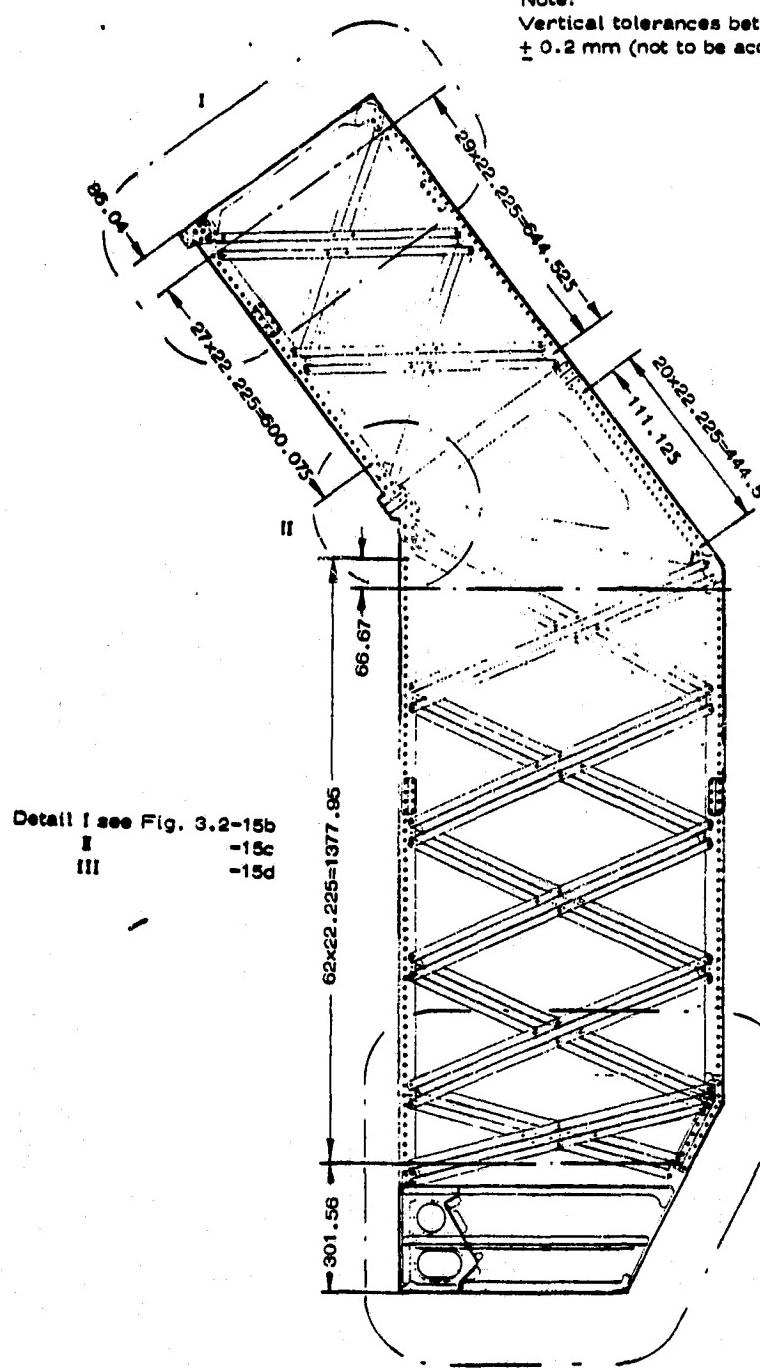
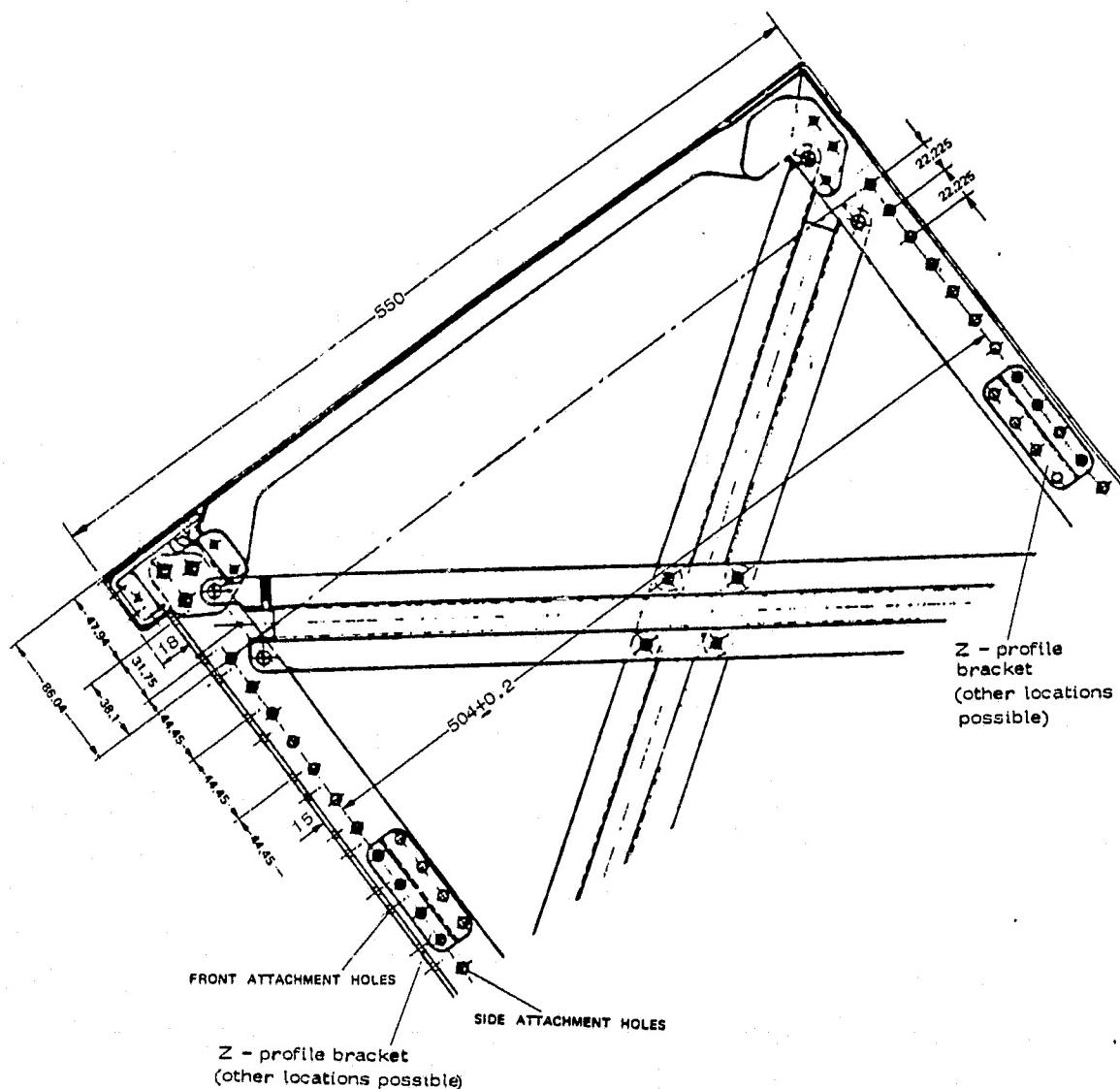


Figure 3.2 - 15a: Side Attachment Middle Frame

DETAIL 1



Note:

Tolerances between any two mounting holes ± 0.2 mm
(not to be accumulative)

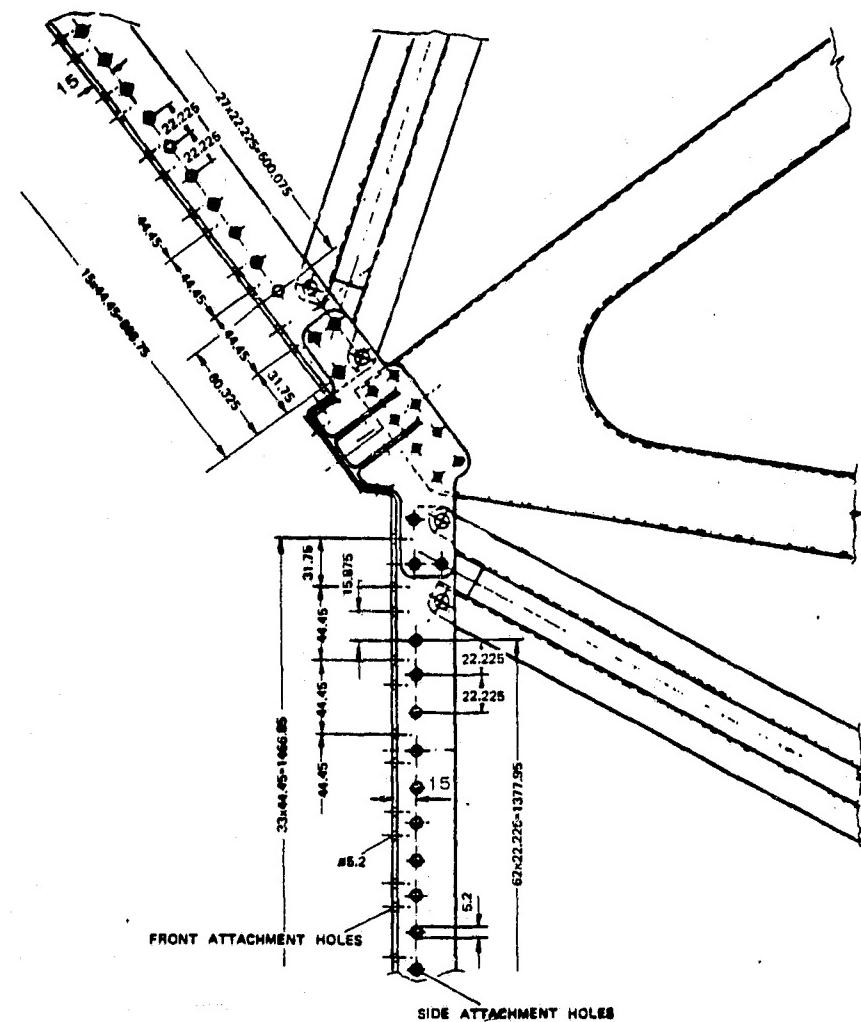
Figure 3.2 - 15b : Detail 1 (Side Attachment Middle Frame)

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DETAIL II



Note:
Tolerances between any two mounting holes ± 0.2 mm
(not to be accumulative)

Figure 3.2 - 15c : Detail II (Side Attachment Middle Frame)

DETAIL III

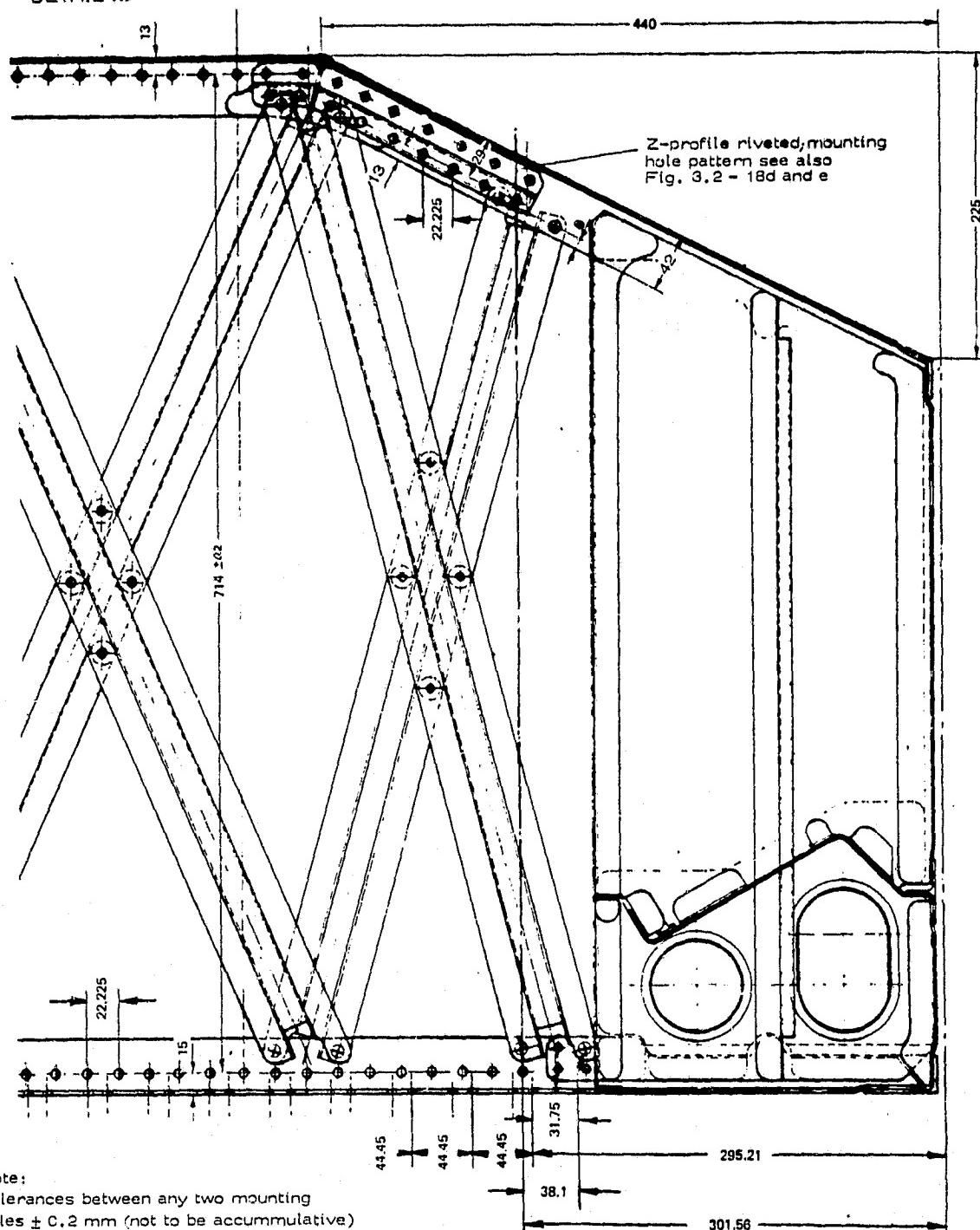


Figure 3.2 - 15d : Detail III (Side Attachment Middle Frame)

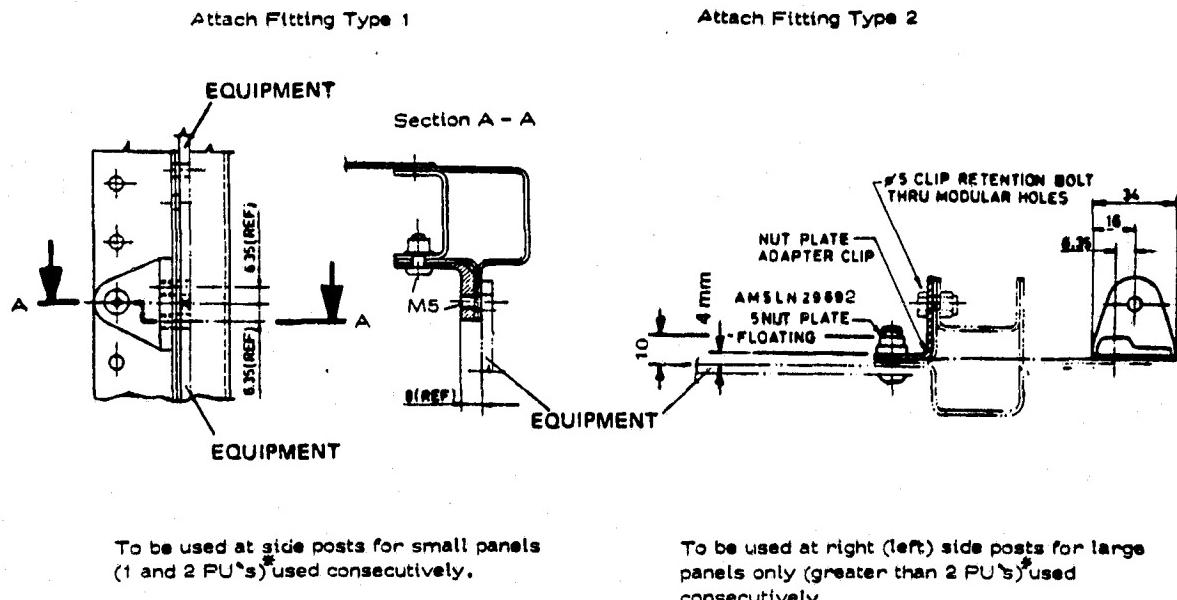
3.2.2.2.3 Attachment Aids

Spacelab provides a set of special attachment fittings for equipment installation on front posts. The various types of attachment fittings are shown in Figure 3.2 - 15e; the quantity delivered by Spacelab is given in Table 3.2 - 1.

Figure 3.2 - 15f shows the types of Z-fittings for equipment support on the front and the rear middle post of a double rack. These fittings are mandatory whenever additional support structures must be used for equipment installation. Type 1 will be delivered by Spacelab to be used for cable tie struts; hence additional quantities will have to be provided by the user.

Type 2, 3 and 4 are shown for information only and are to be supplied by the user.

Respective examples of equipment support schemes are shown in Figure 3.2 - 19.

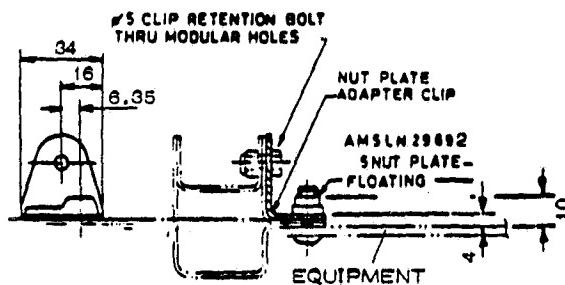


* PU = Panel Unit

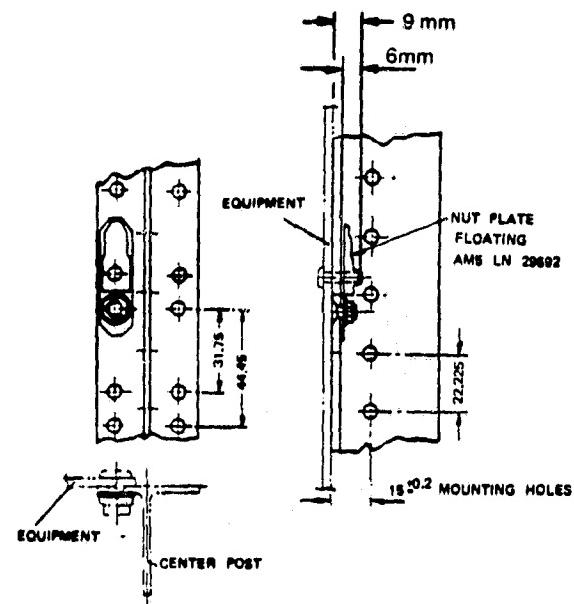
Figure 3.2 - 15e : Attachment Fittings

Attach Fitting Type 4

Attach Fitting Type 3



To be used at left (right) side posts for large panels only (greater than 2 PU's)* used consecutively



To be used at center post for large panels only (greater than 2 PU's)* used consecutively

Attach Fitting Type 5

Attach Fitting Type 6

TBD

TBD

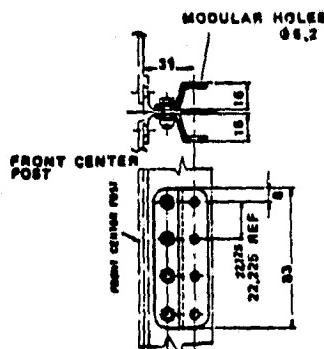
To be used only at the ends of the center post for small panels (2 PU's)*

To be used at the center post for small panels (1 and 2 PU's)* used consecutively

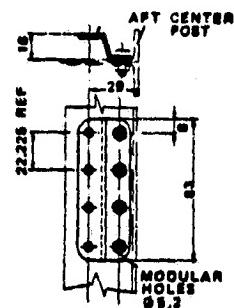
* PU = Panel Unit

Figure 3.2 - 15e : Attachment Fittings

Z-Fitting Type 1

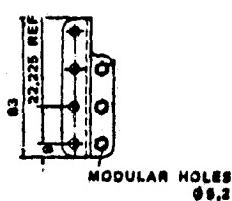


Type 1 as used at rear center post



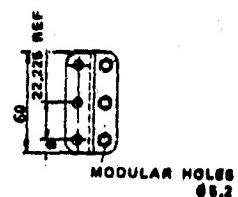
Type 1 as used at front center post

Z-Fitting Type 2



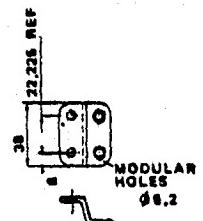
for information only

Z-Fitting Type 3



for information only

Z-Fitting Type 4



for information only

Figure 3.2 - 15f : Center Post Z-Fittings

3.2.2.3 Rack Structural Elements

3.2.2.3.1 Diagonal Shear Load Strut

Removable diagonal shear load struts, stiffening the racks can be installed in various locations of the lower part of double and single racks.

Two shear load strut sets are foreseen for each single rack and for each side of a double rack. In a double rack the diagonal shear load struts can be independently installed on each side of the rack. The overall load carrying capability of a rack as a function of number and position of shear load struts installed is given in section 3.2.6.1.

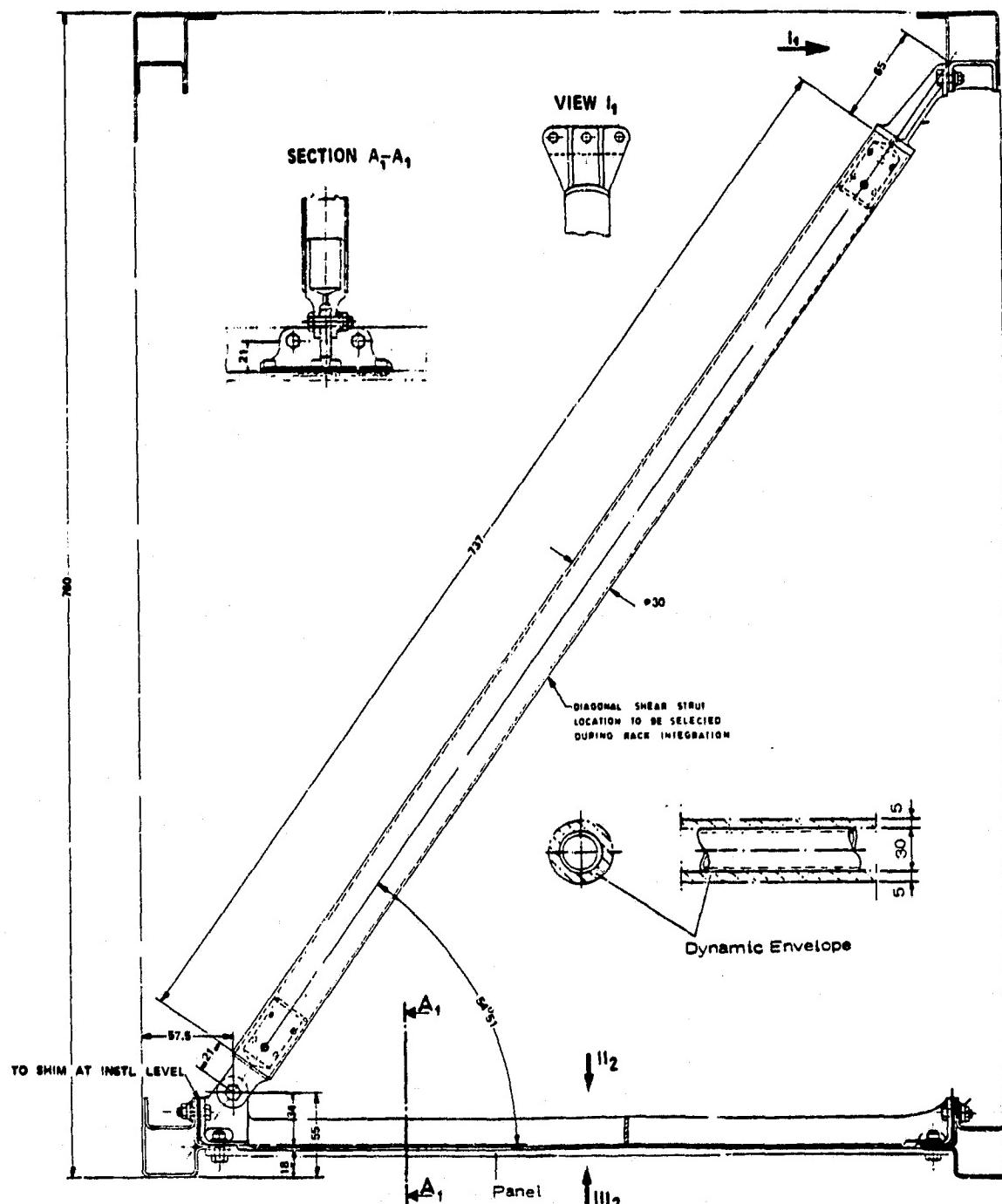
There are fixed diagonal shear load struts in the upper part of double and single racks. These fixed diagonal shear load struts do not affect experiment installation activities directly. However, they are shown here in this section due to potential interference with utility routing and accessibility.

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View II₂ and III₂ see Fig. 3.2 - 16c

Figure 3.2 - 16a: Removable Diagonal Shear Load Strut - Single Rack

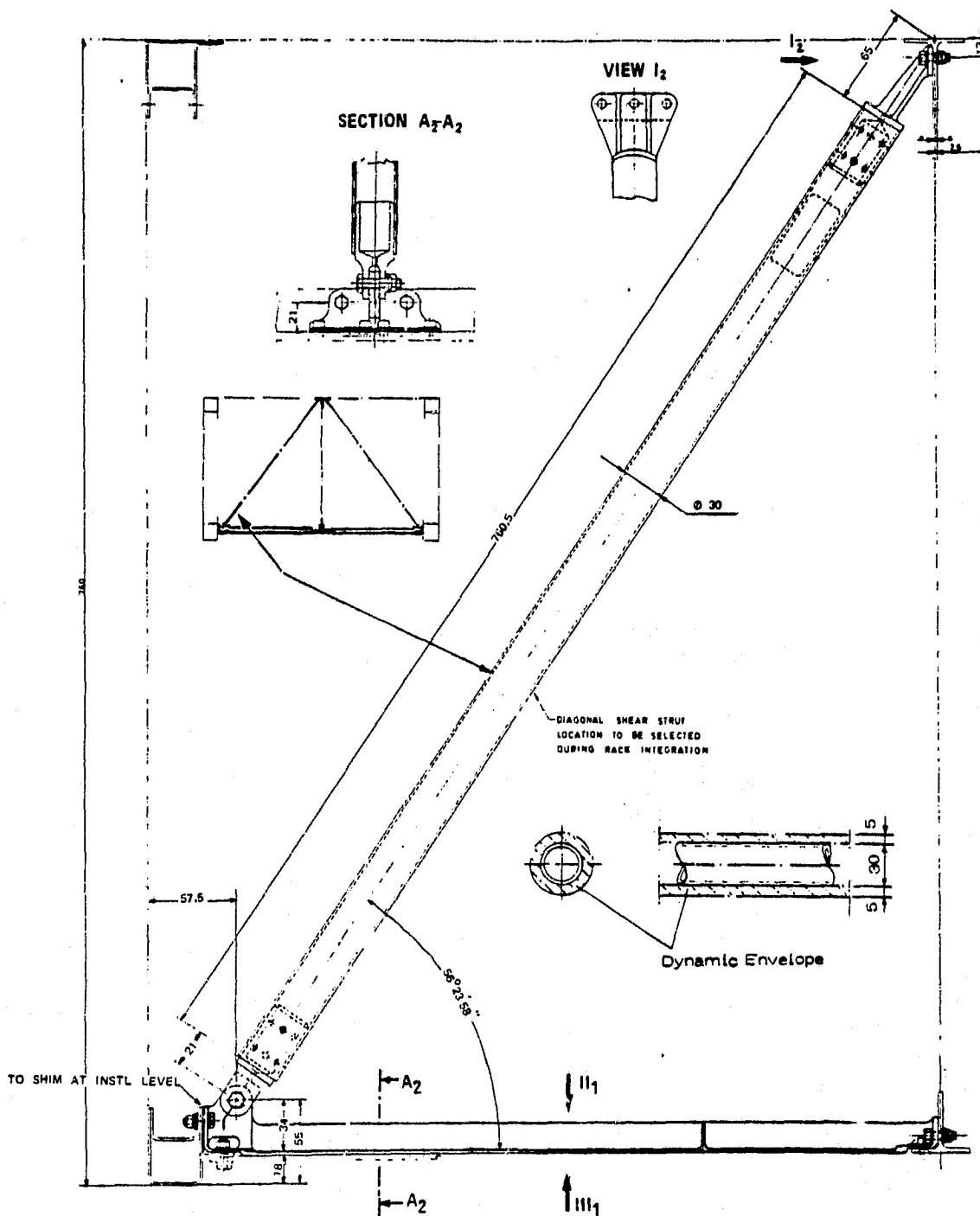
View II₁ and III₁, see Fig. 3.2 - 16c

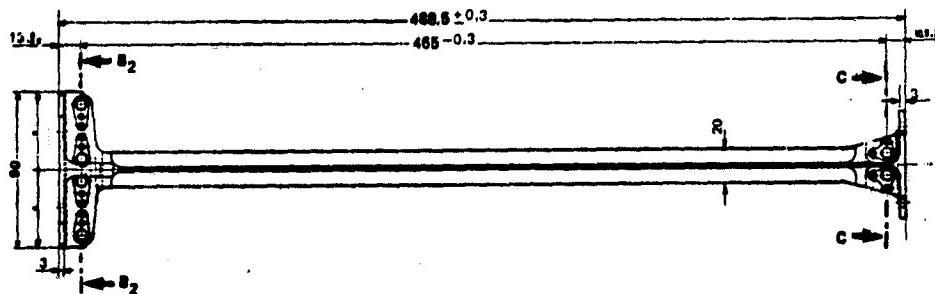
Figure 3.2 - 16b: Removable Diagonal Shear Load Strut - Left Side Double Rack

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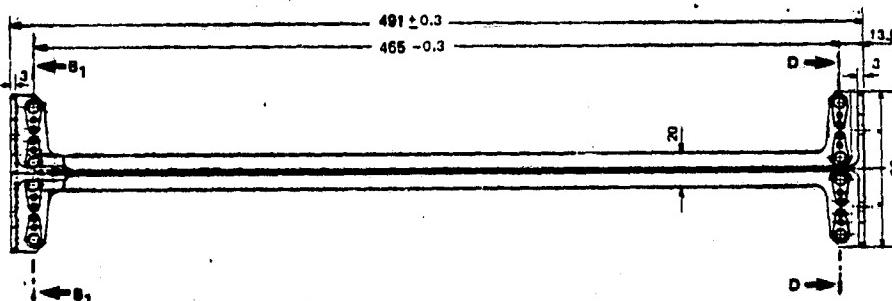
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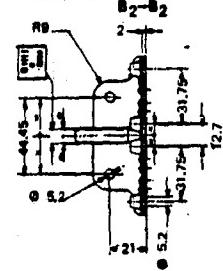
VIEW II, DOUBLE RACK



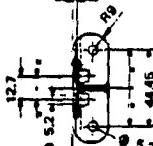
VIEW II, SINGLE RACK



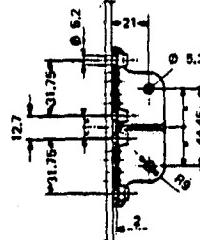
SECTION 8,~8,



SECTION C-C



SECTION D-D



VIEW III₁/III₂ DOUBLE RACK/SINGLE RACK

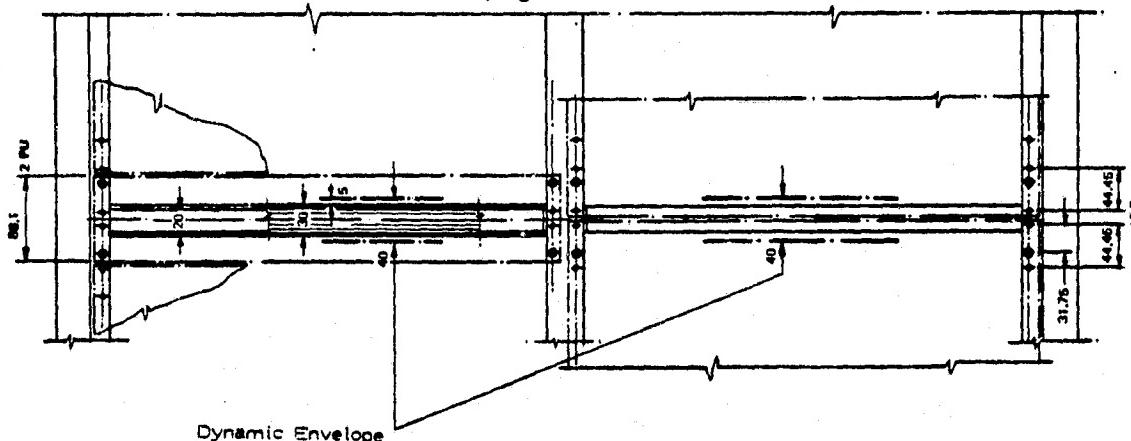


Figure 3.2 - 16c : Shear Load Struts

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SECTION A-A

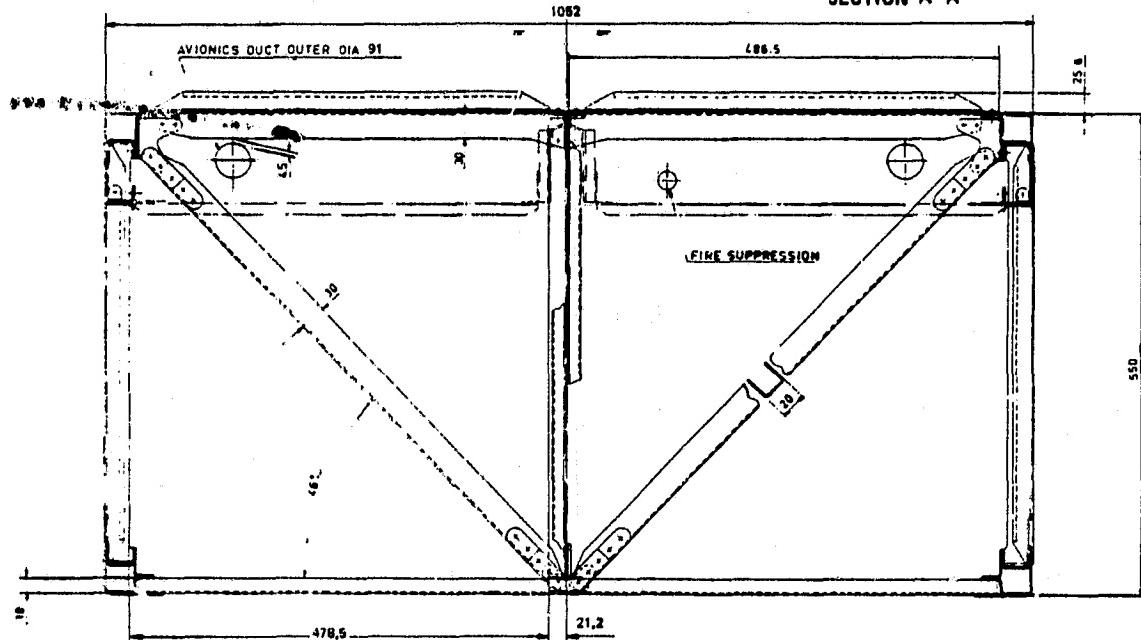
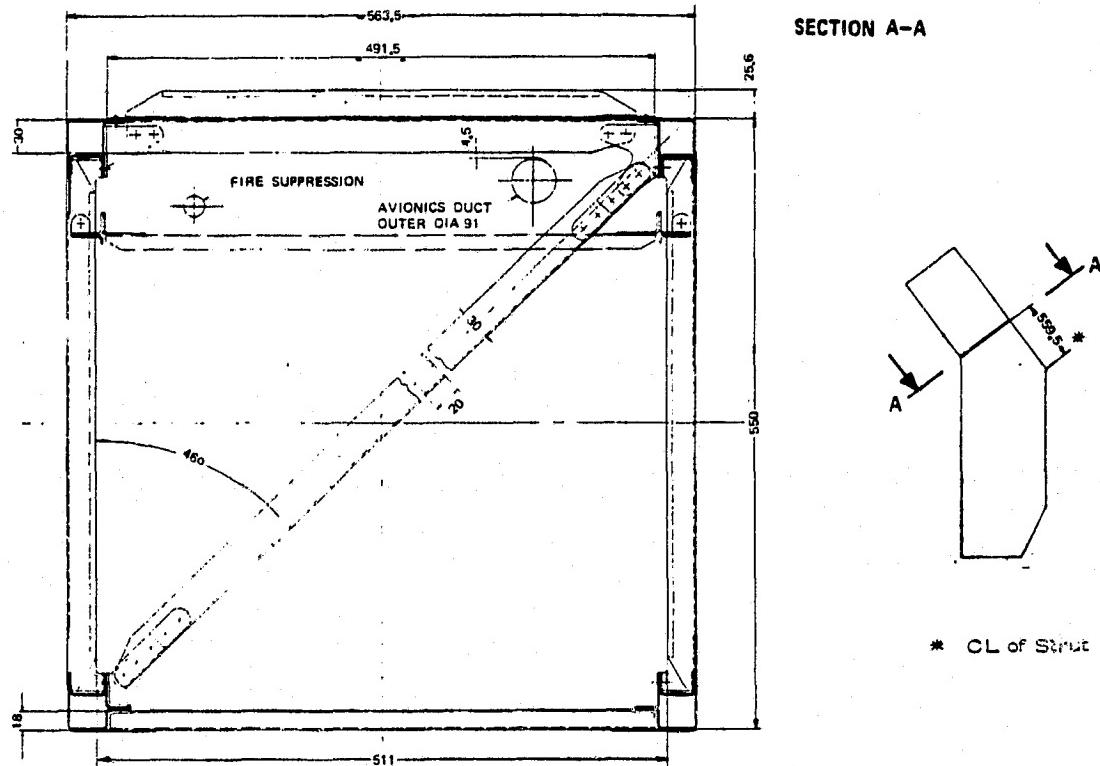


Figure 3.2 - 16d : Fixed Diagonal Shear Strut - Double Rack

SECTION A-A



* CL of Strut

Figure 3.2 - 16e : Fixed Diagonal Shear Load Strut - Single Rack

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3.2.2.3.2 Cable Tie Strut

Cable Tie Struts in the rear of the rack are foreseen to

- support airduct, fire suppression line and subsystem cables
- support experiment utilities

The cable tie struts which support Spacelab subsystems have to stay in positions defined in section 3.2.3.1, Airduct - Fire Suppression Line Configuration.

The other cable tie struts may be installed according to experimenter needs.

In single racks the cable tie struts are mounted to vertical hole rows attack to the rack side panels.

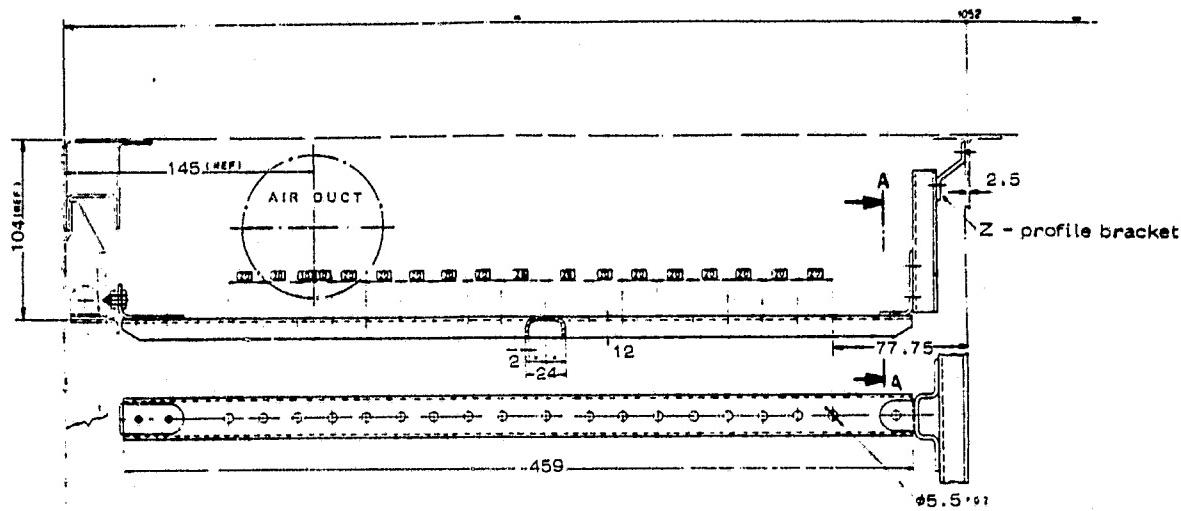
In double racks the mounting at the outer sides is the same. However, at the middle frame each cable tie strut is mounted through a dedicated bracket to the experiment side attachment holes at the rear. This potential interference between experiment support structure and cable tie struts must be taken into account for experiment accommodation in the racks.

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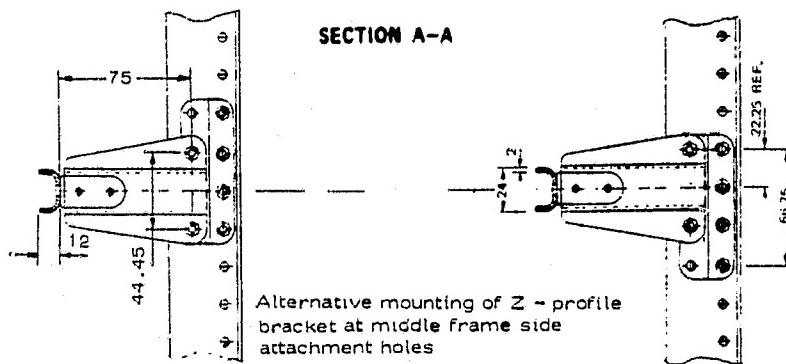
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DOUBLE RACK



SECTION A-A



SINGLE RACK

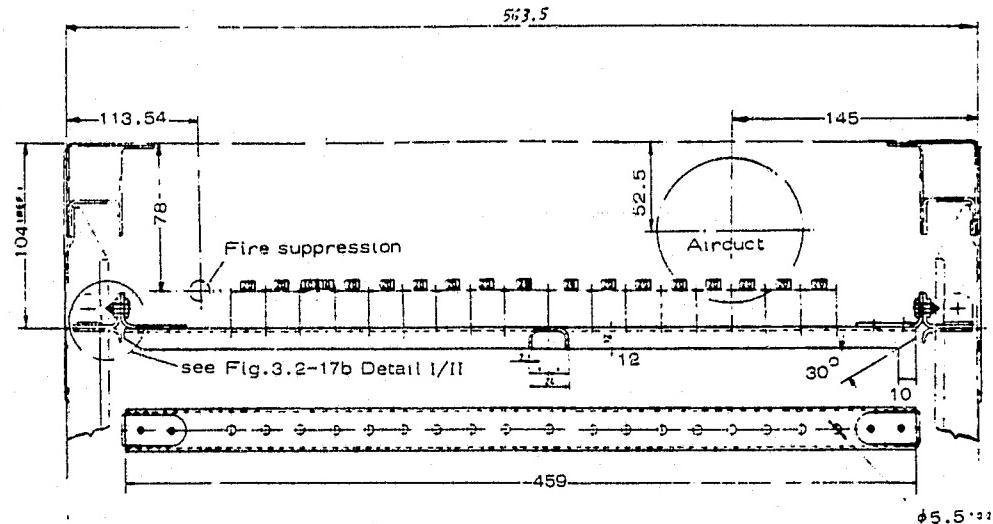


Figure 3.2 - 17a: Cable Tie Strut Configurations

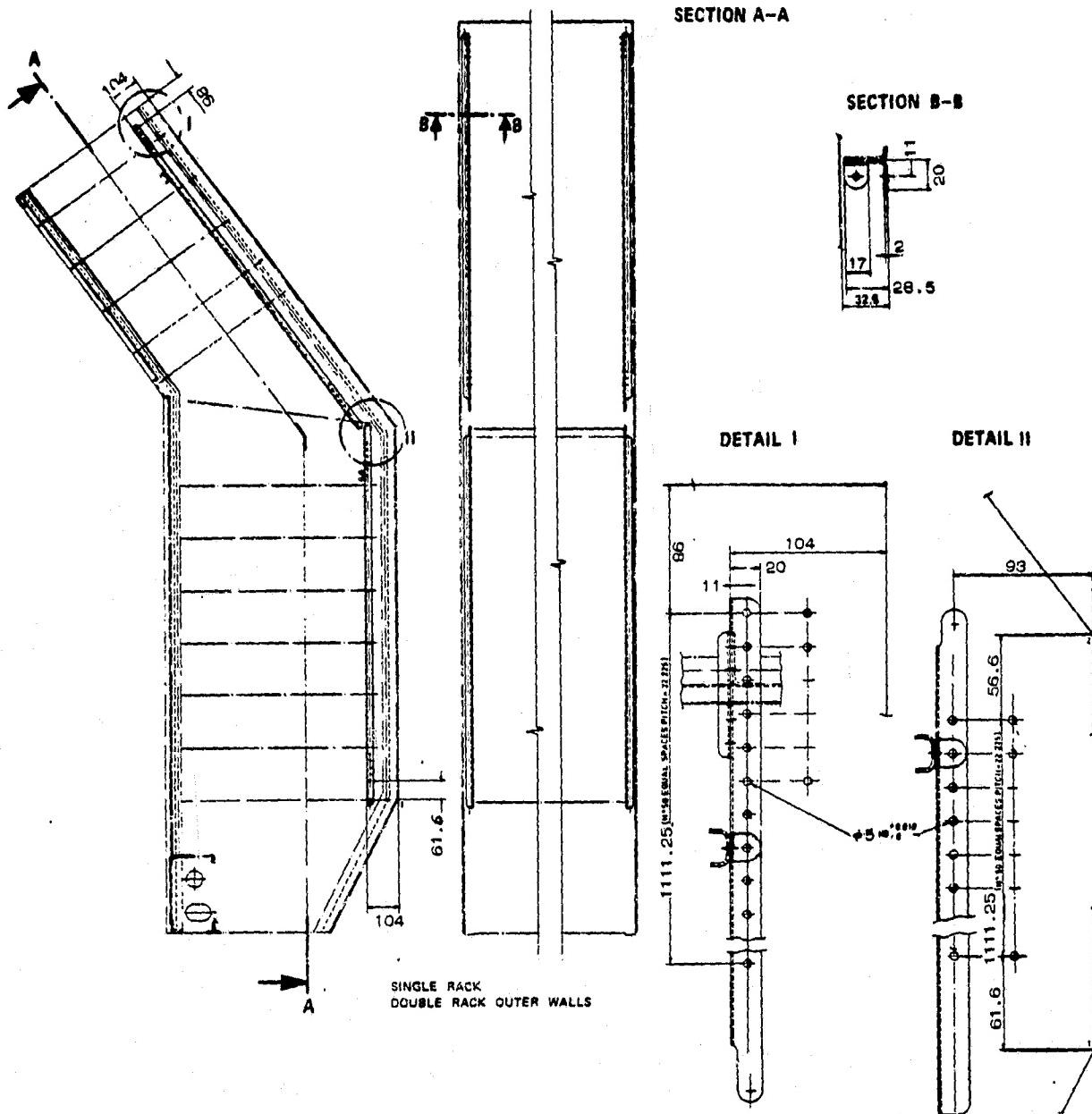


Figure 3.2 - 17b: Cable Tie Strut Interface - Side View

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3.2.2.3.3 Middle Frame

The upper middle frame of an experiment double rack is an essential structural element which may be removed only temporarily to ease integration activity.

The lower middle frame of an experiment double rack is removable. The load carrying capability of the rack with removed lower middle frame is subject of a case by case analysis. However, if the middle frame is removed RAU and EPSP can only be installed by means of user provided substructures.

Therefore, unless hardware is provided by the user which partly takes over the functions of the middle frame, the removal of the middle frame is possible only in racks which are used for completely passive stowage.

When the middle frame is not installed the rack/middle frame attachment interface is available for users. However, load data for these interfaces are not provided.

Details of the rack/middle frame interface are shown in Figure 3.2 - 18

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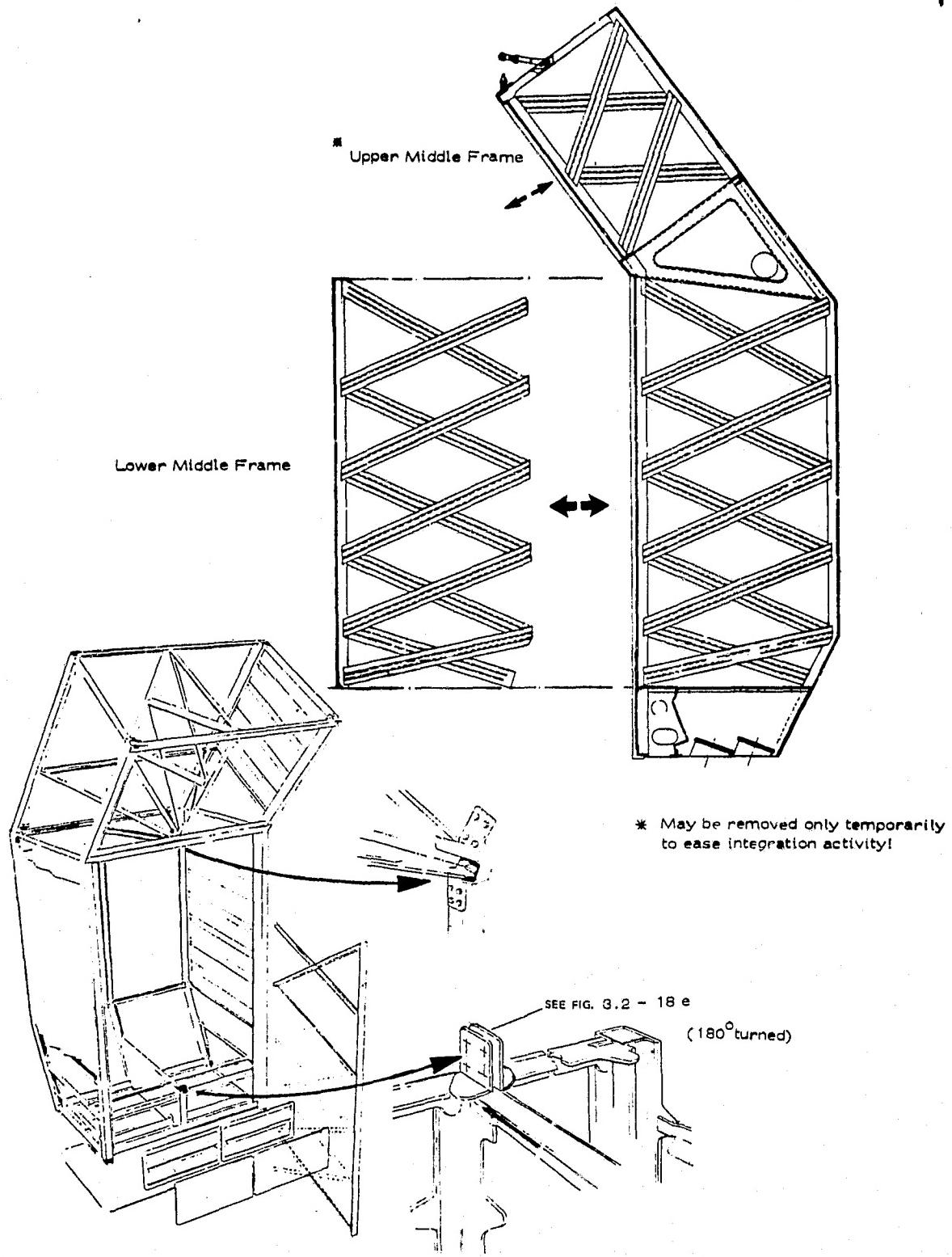
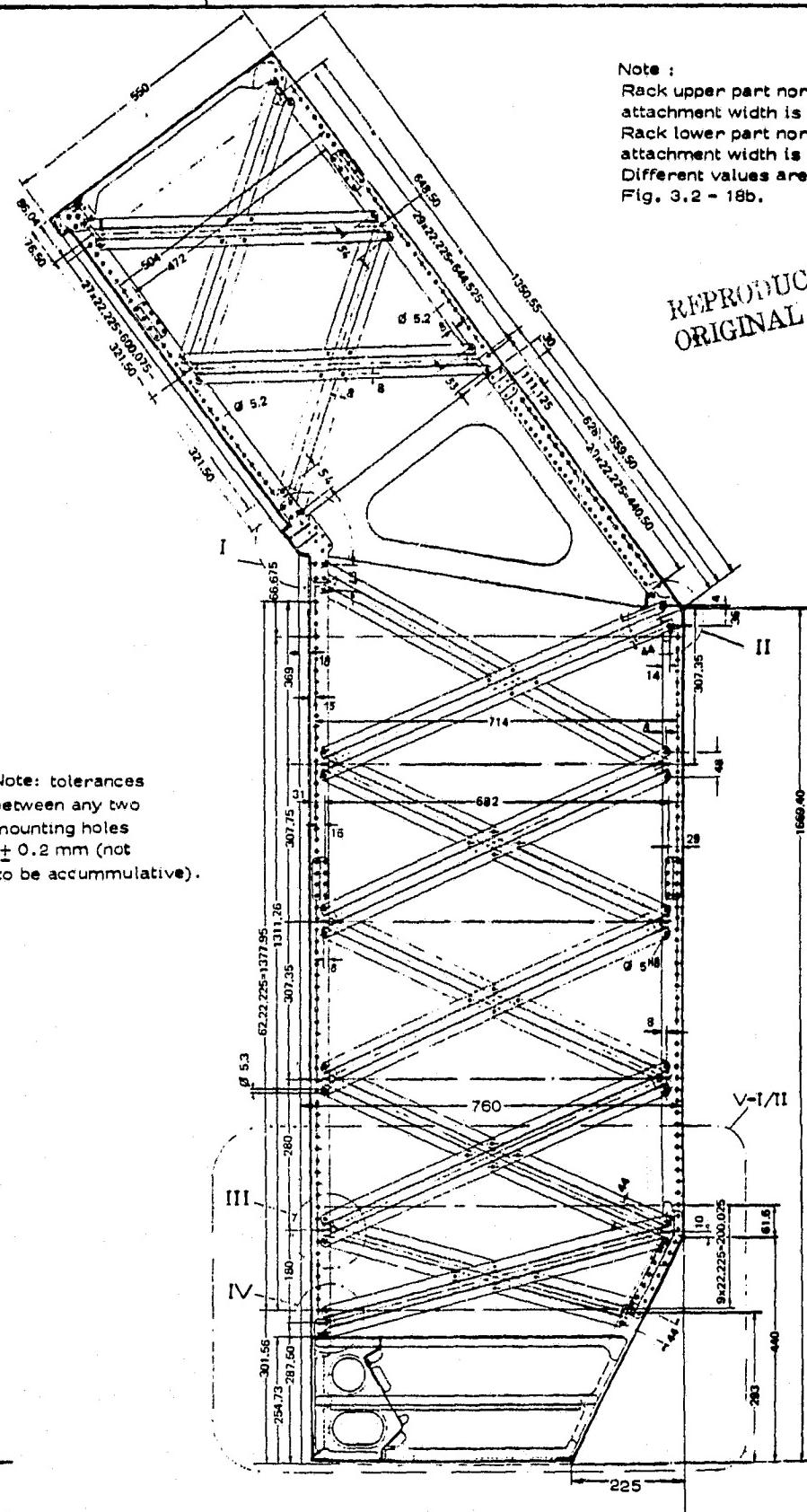


Figure 3.1 - 18a : Double Rack Middle Frame

Figure 3.2 - 18b:
Middle Frame

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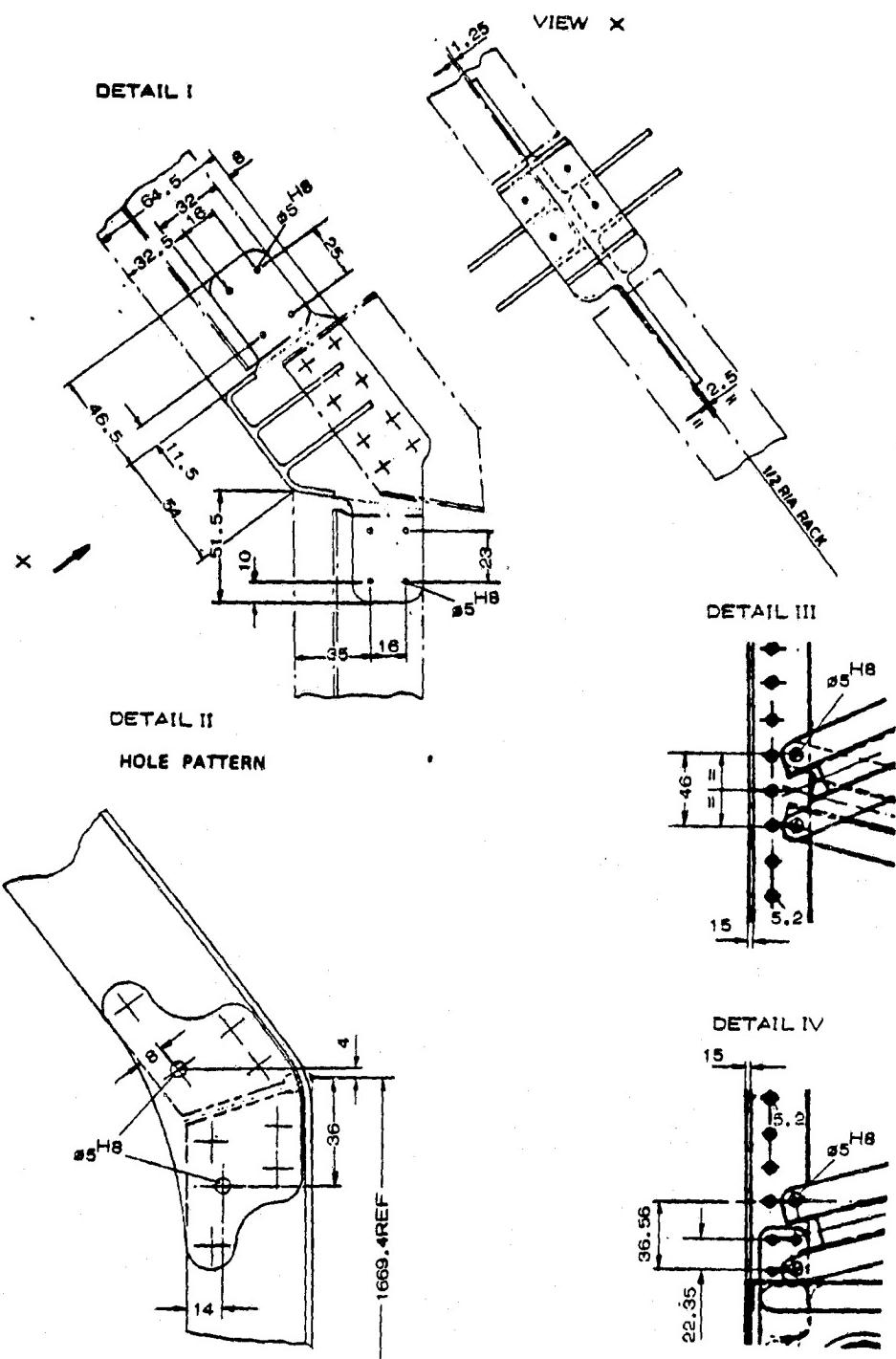


Figure 3.2 - 18c : Middle Frame Rack Interface

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DETAIL V-1

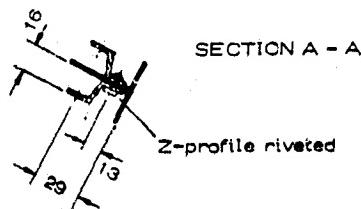
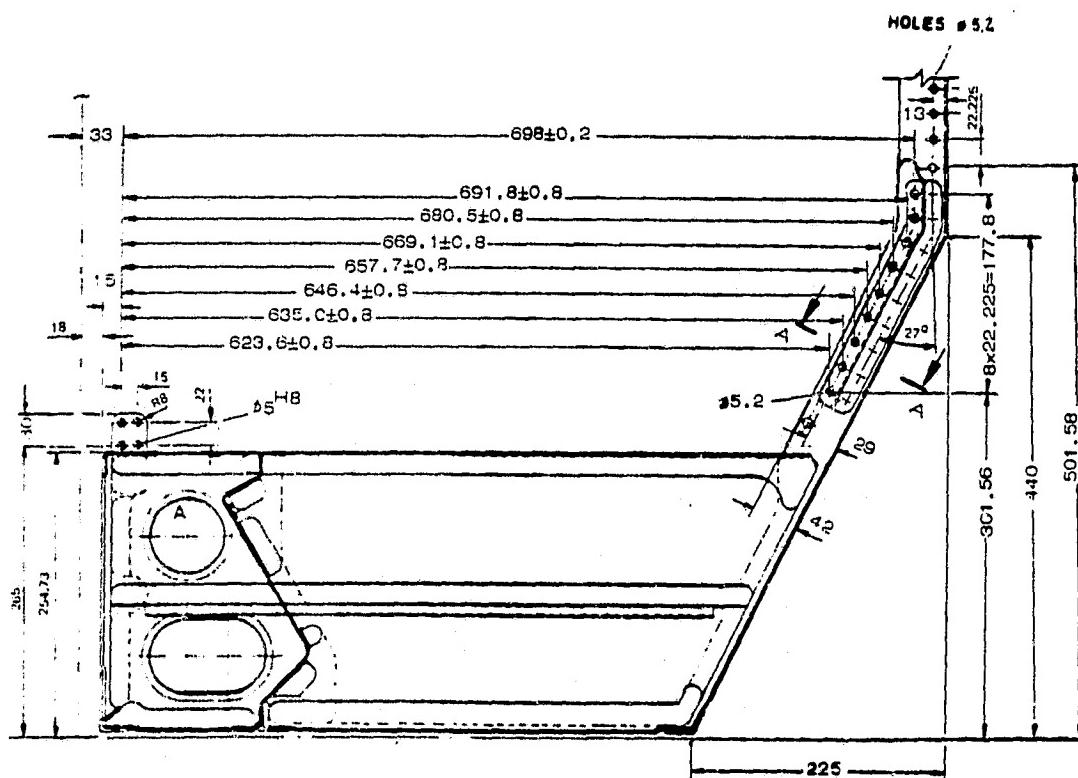


Figure 3.2 - 18d ; Double Rack, Hole Location at Lower Z-Profile

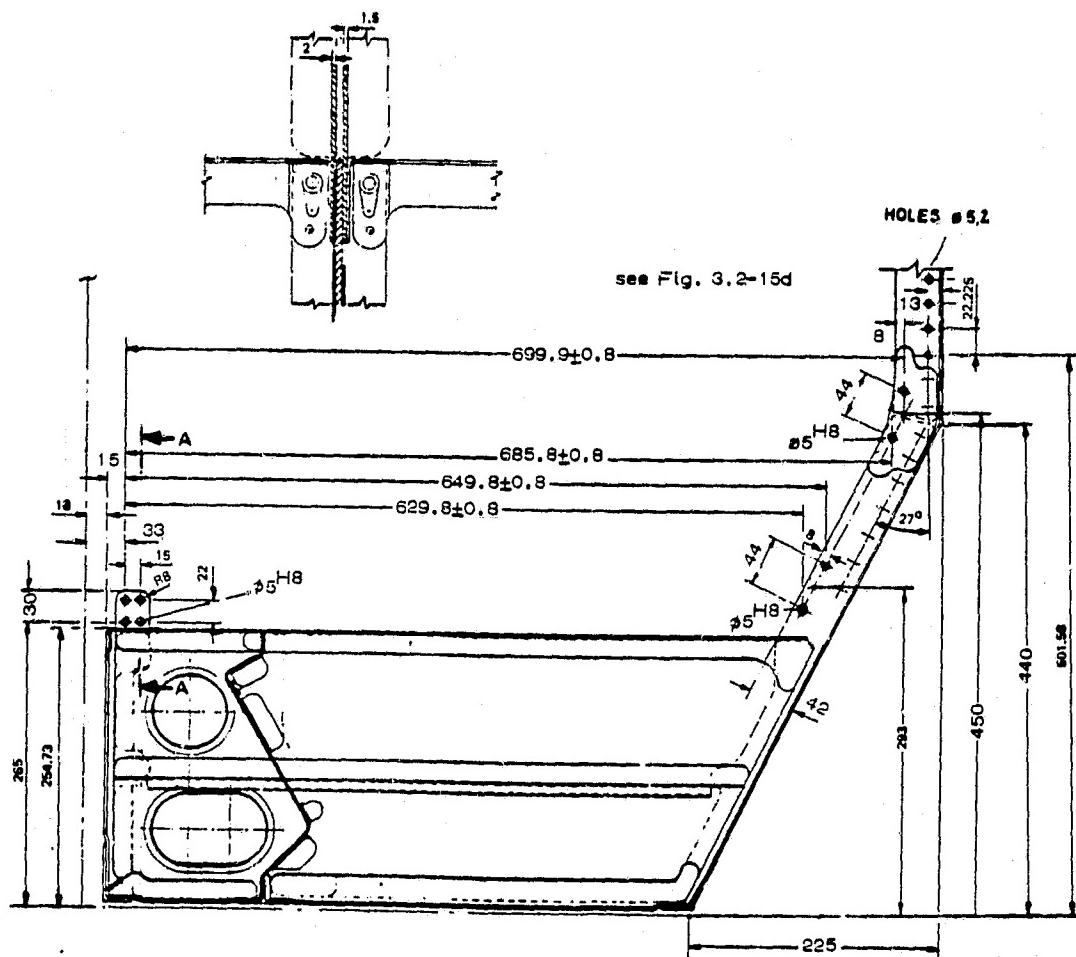
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DETAIL V-II

SECTION A-A



Note: T-profile interface, riveted Z-profile not shown

Figure 3.2 - 18a: Middle Frame Rack Interface at T-Profile

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3.2.2.4 Examples of Experiment Attachment

The modular rack concept provides for the accommodation of other support structure in addition to that normally provided by Spacelab. Such equipment will be user supplied, examples of which might include shelving and supports for equipment in accordance with ARINC 404 A. Examples of such support structures together with a typical method of attachment to the rack structure is given in Figure 3.2 - 19 a for single racks and in Figure 3.2 - 19 b for double racks. Details of typical support structure cross-sections are given in Figure 3.2 - 19 c. Details of equipment mounting support are shown in Figure 3.2 - 19 d.

Stiffness of the support structure is recommended to have $35 \leq f_0 \leq 60$ Hz, otherwise mass should be reduced in accordance with the accelerations given in para 3.2.7.

For the design of equipment boxes, it is important to check carefully, where it is possible to attach user provided structures to the rear posts for support, considering the existing cable tie struts, diagonal shear load struts, etc.

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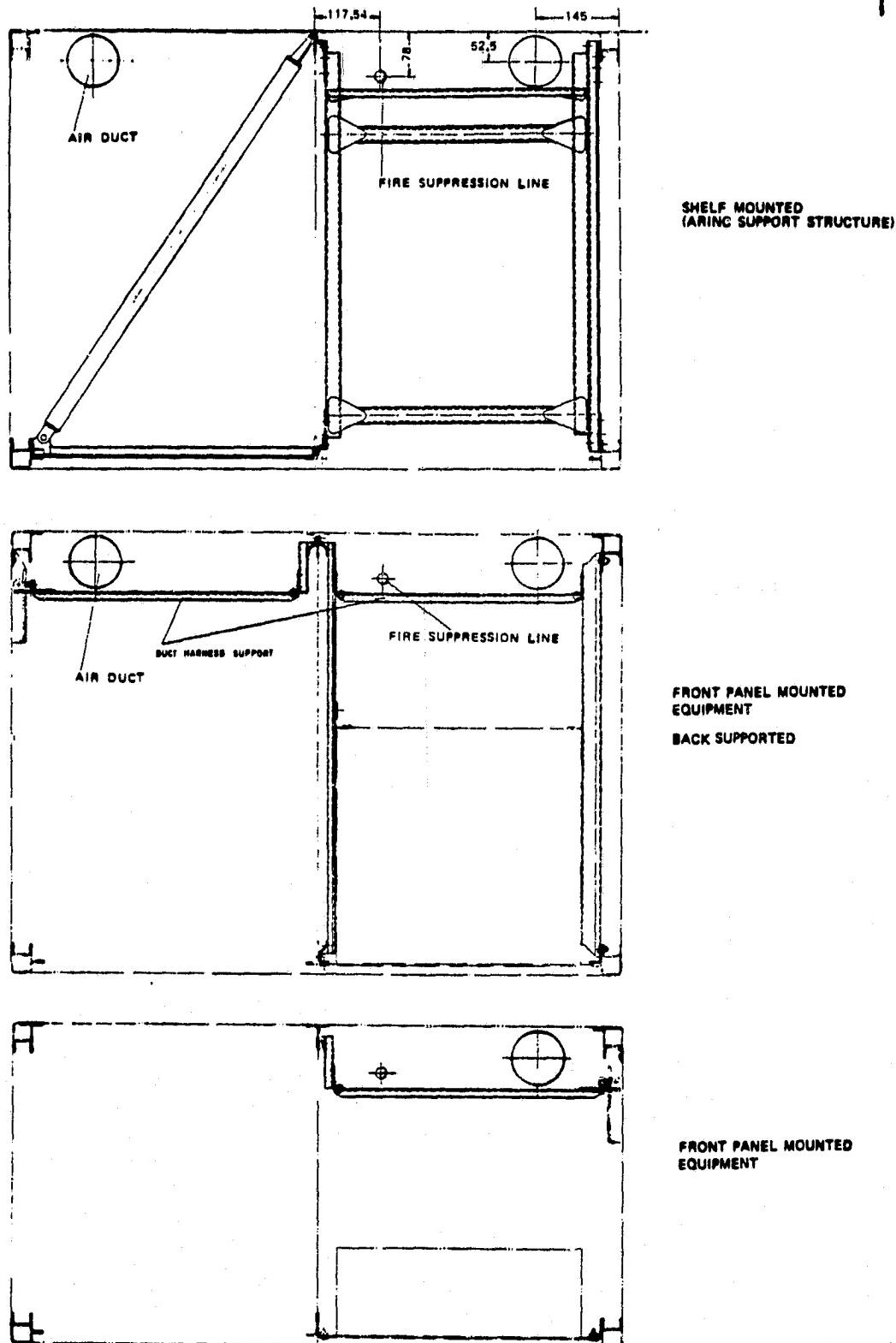


Figure 3.2 - 19a: Examples of Experiment Mounting Supports

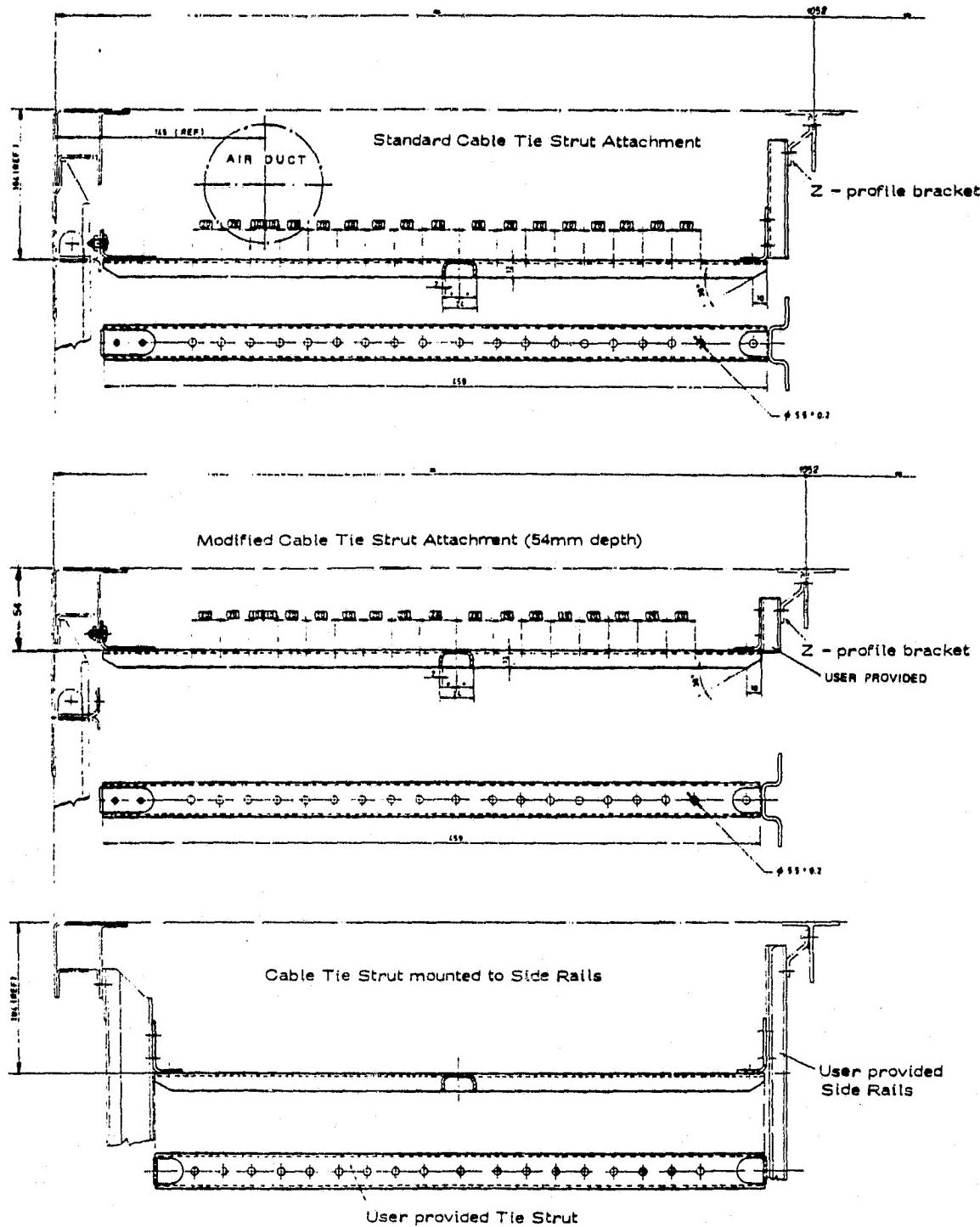
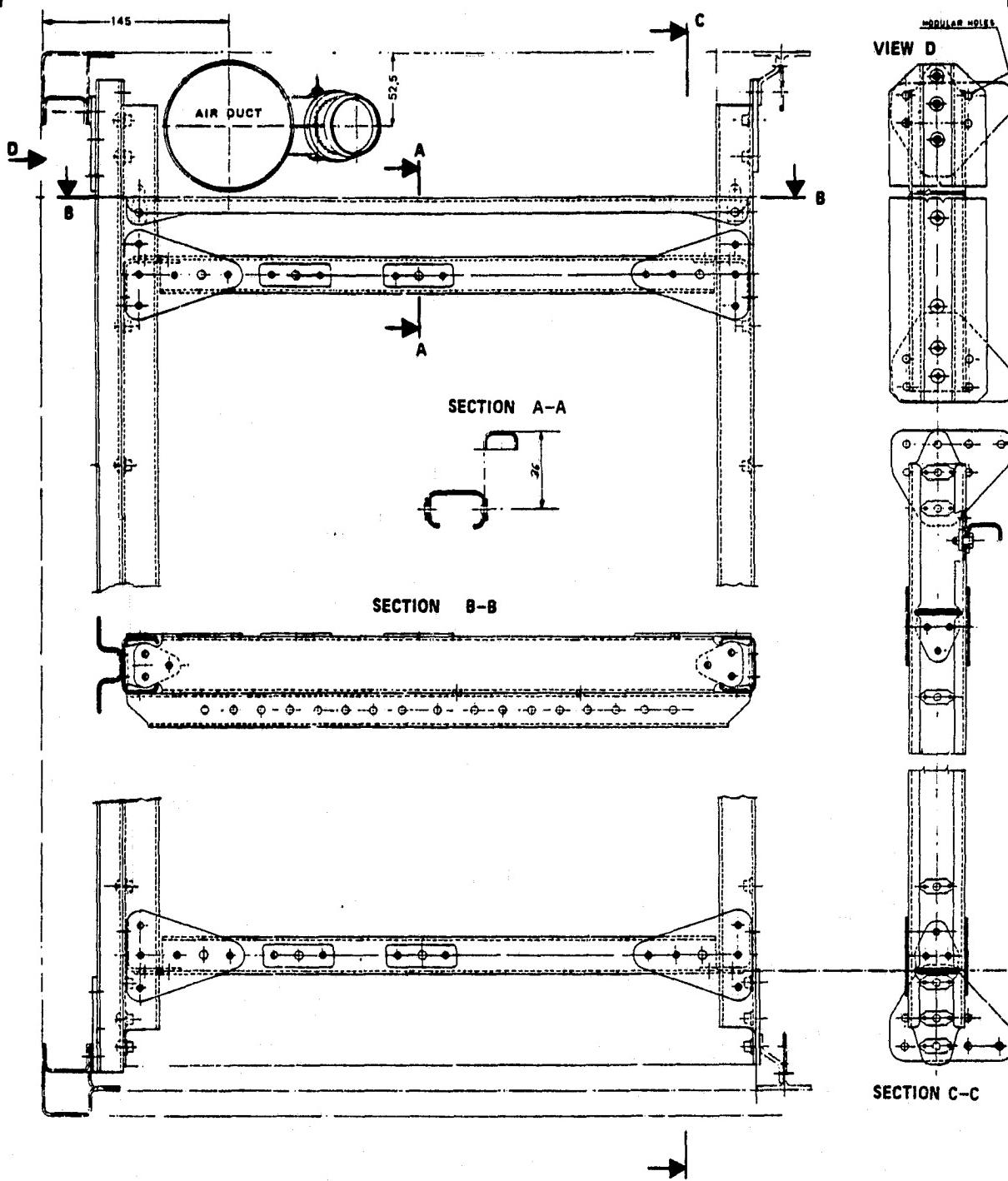


Figure 3.2 - 19b: Example of Cable Tie Strut Interface

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DOUBLE RACK
ARINC SUPPORT SHOWN FOR INFORMATION ONLY
ONE TYPICAL METHOD TO INTERFACE WITH THE
RACK STRUCTURE

Figure 3.2 - 19c: Example - Double Rack Equipment Support

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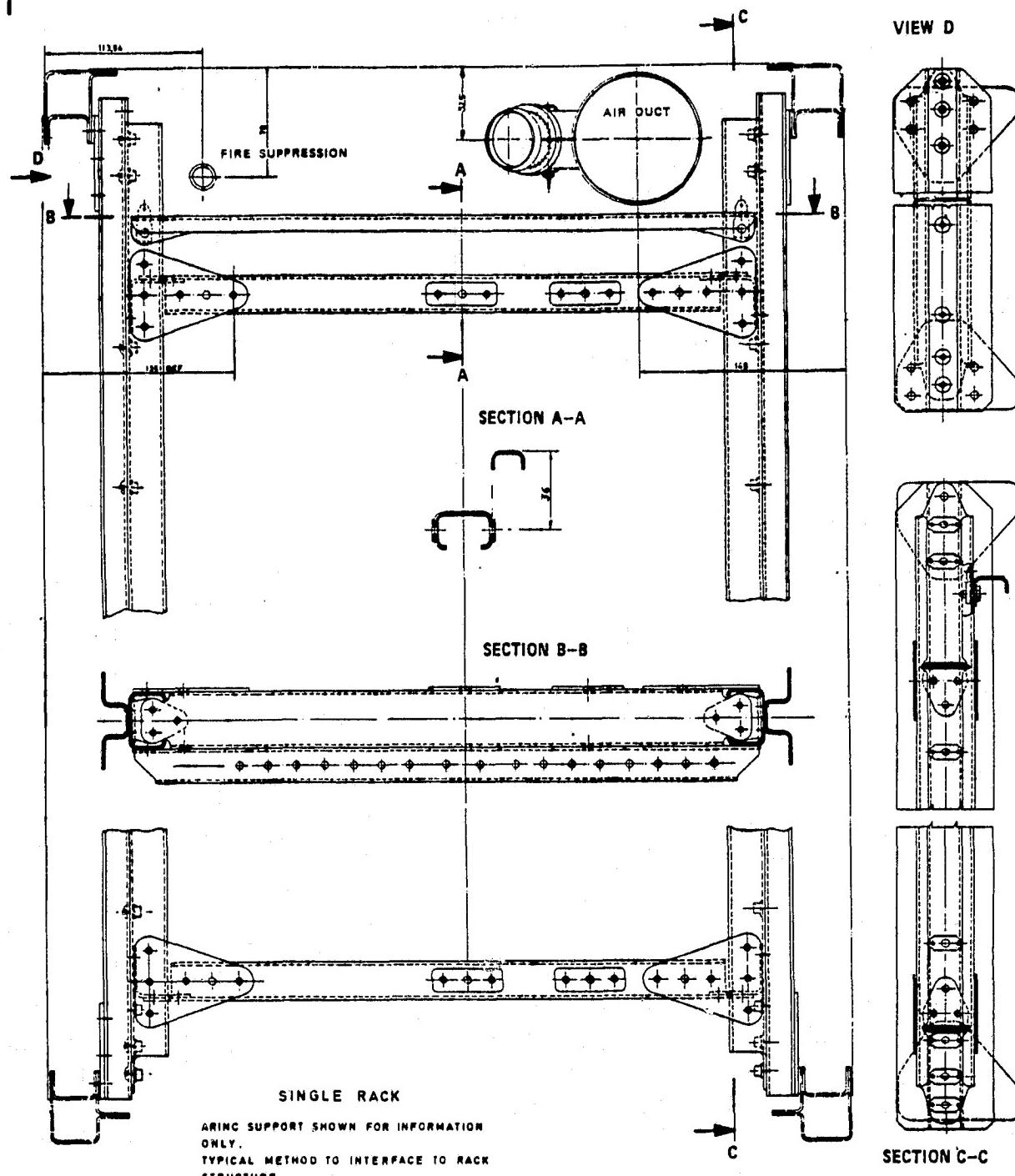


Figure 3.2 - 19d: Example - Single Rack Equipment Support

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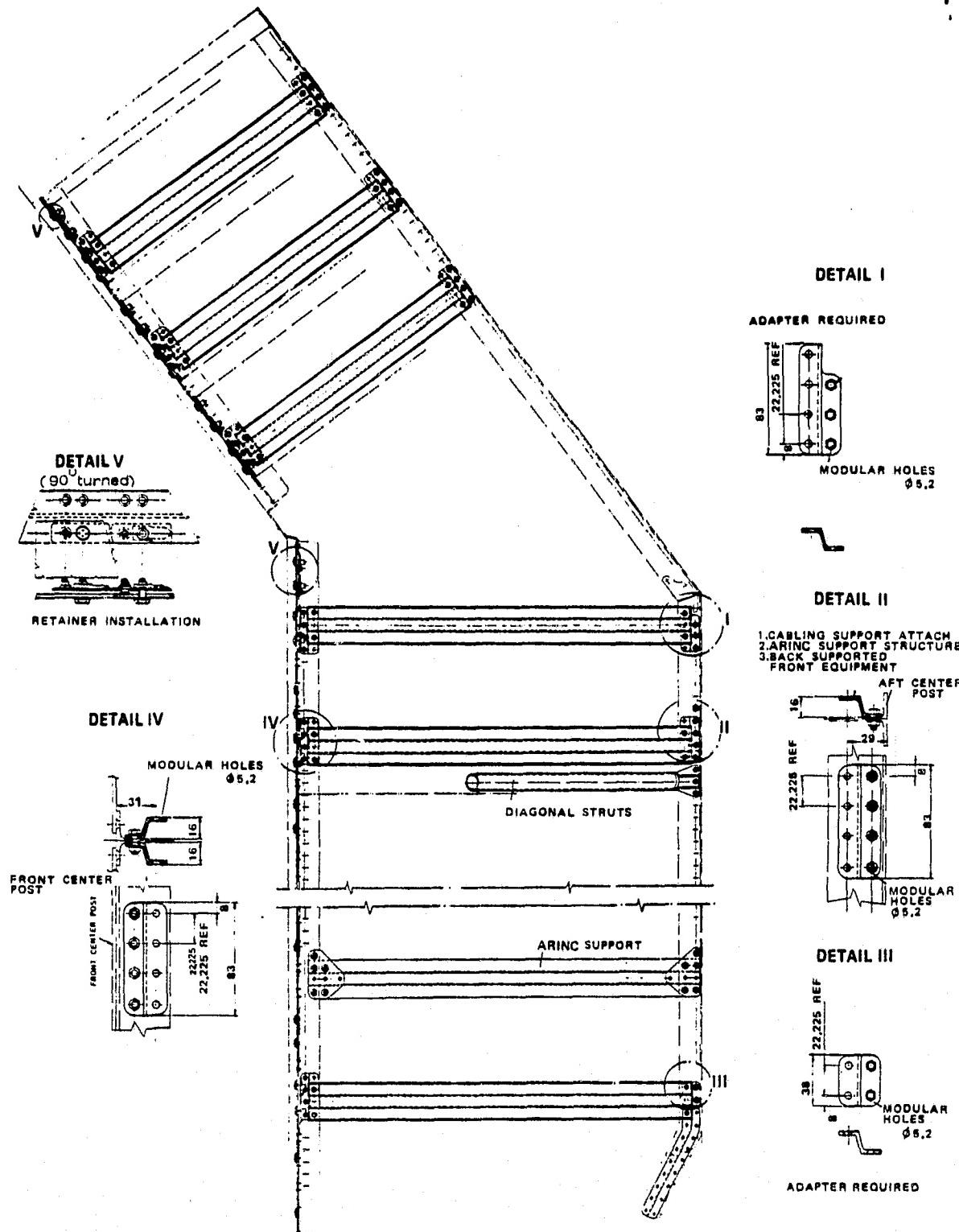


Figure 3.2 - 19e: Example - Support Structure Side View

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3.2.3 ECS - Interface

3.2.3.1 Air Ducts

3.2.3.1.1 Air Duct - Fire Suppression Line Configuration

Air ducts and fire suppression line are attached to the rack by means of the cable tie struts. The particular cable tie struts which support air duct and fire suppression line cannot be removed or changed in their position.

The configuration of these non-removable cable tie struts is given in Figure 3.2 - 20 and 3.2 - 21.

Spacelab provides caps to close the openings of the supply and return air duct in case that the experiment racks are not used.

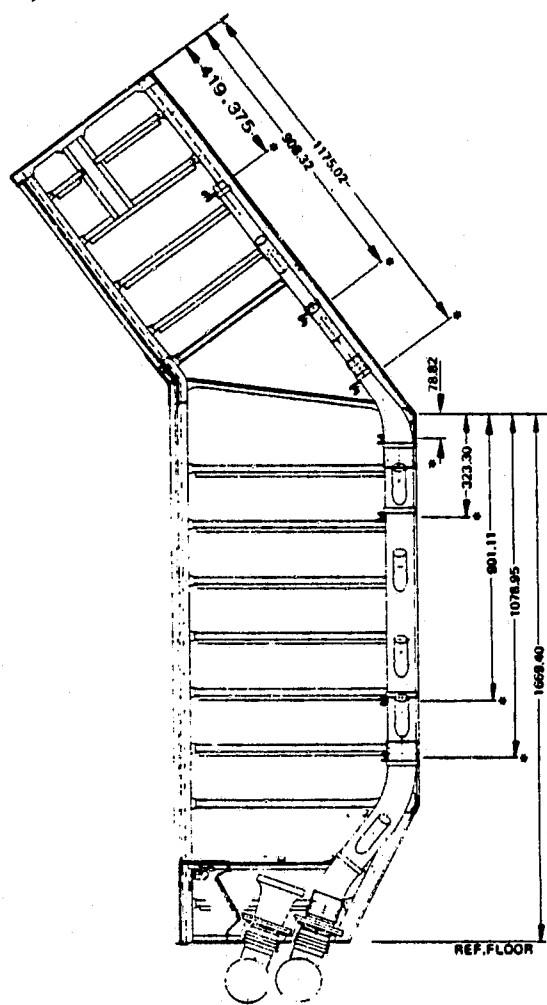
Four (4) caps for each double rack and two (2) caps for each single rack will be delivered.

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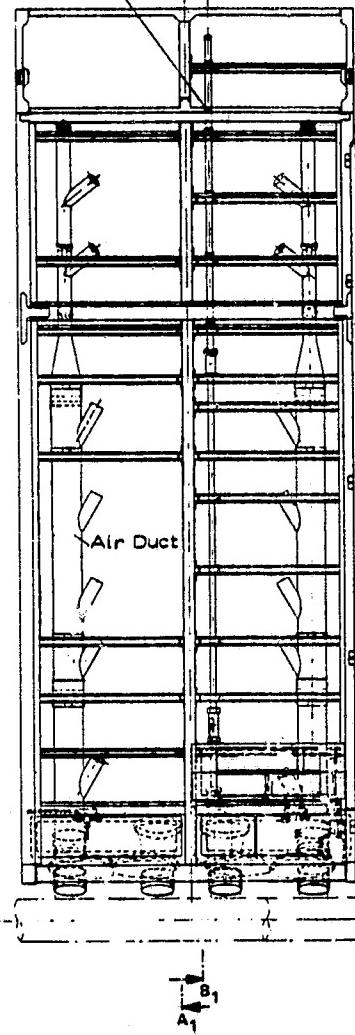
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SECTION A₁-A₁

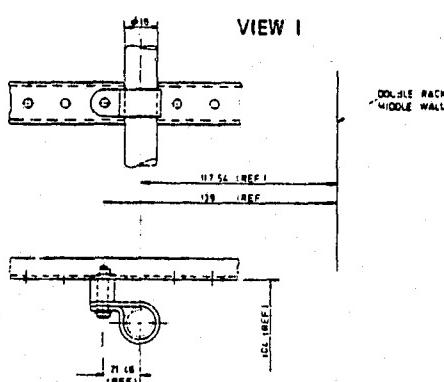
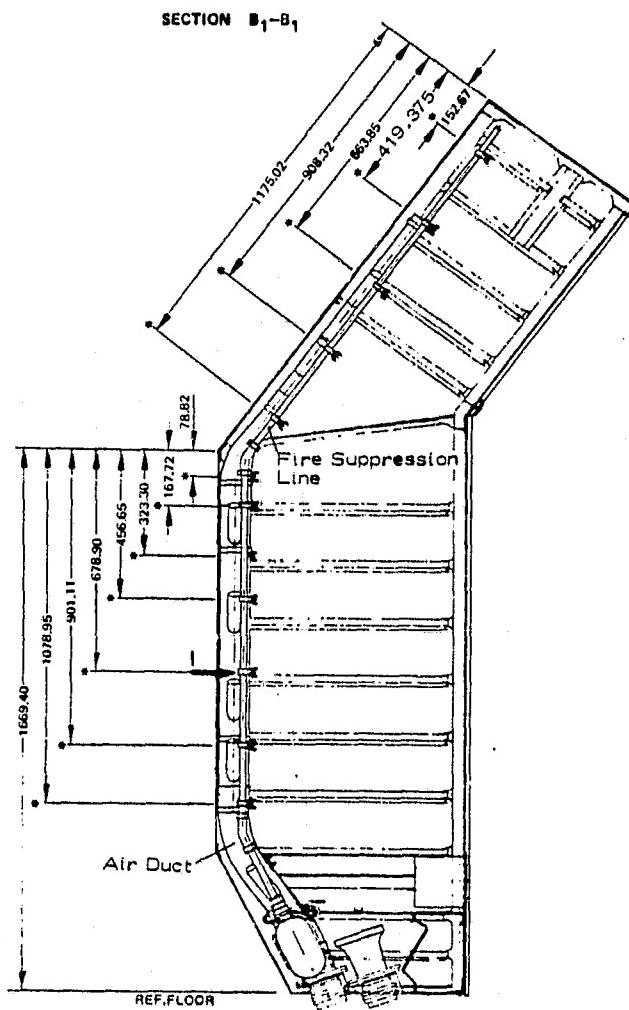


Fire Suppression Line
A₁



* CABLE TIE STRUTS USED FOR FIRE SUPPRESSION LINES AND
AIR DUCTS ARE FIXED WITHIN TOLERANCES OF $\pm 2\text{mm}$.

Figure 3.2 - 20a: Air Duct and Fire Suppression Line Location - Double Rack



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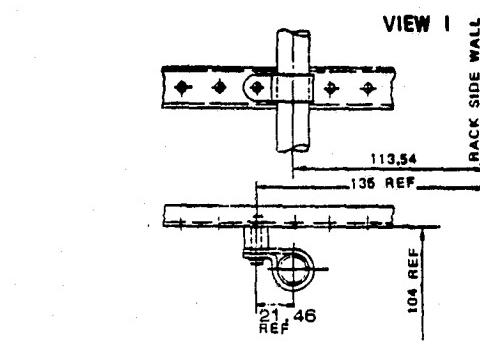
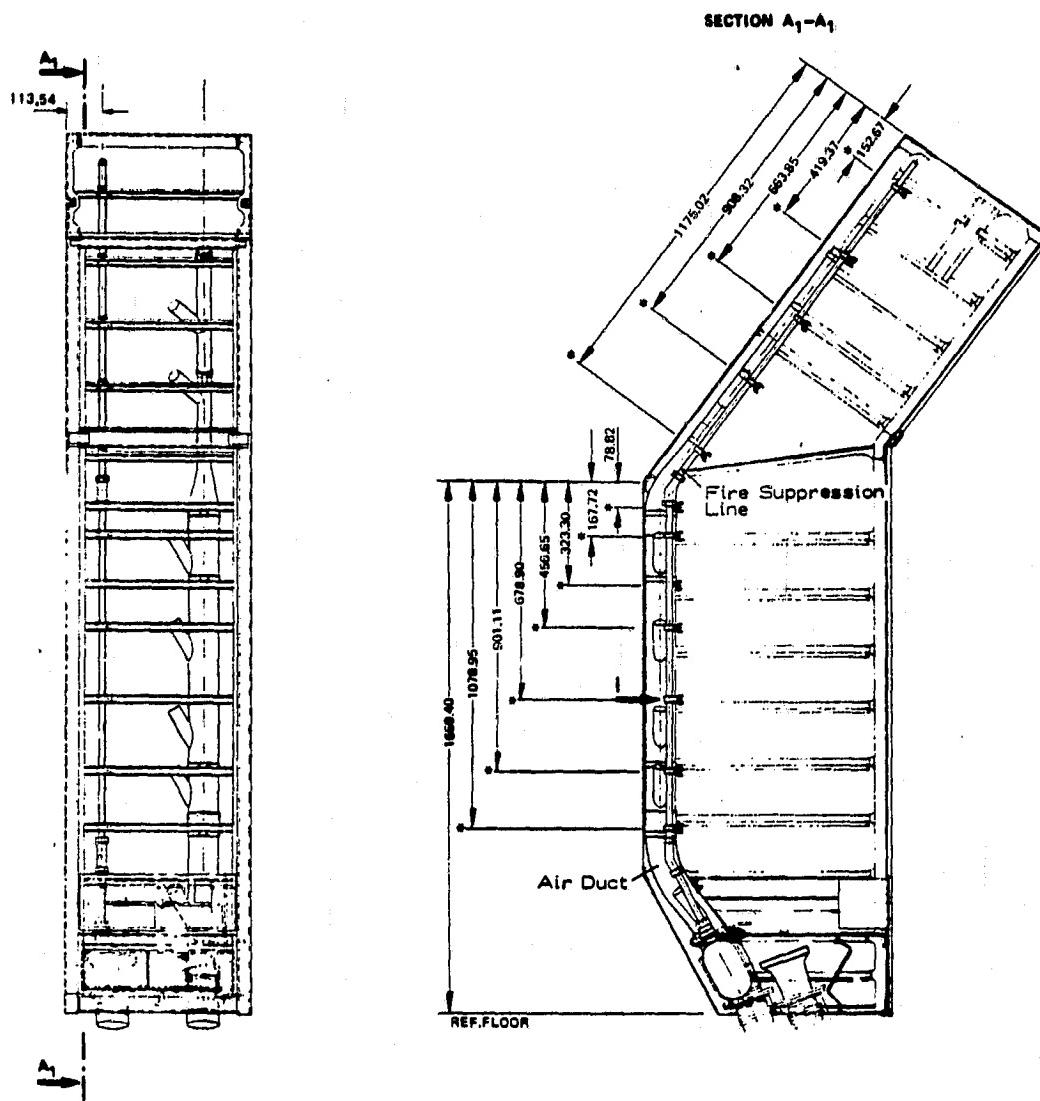
* CABLE TIE STRUTS USED FOR FIRE SUPPRESSION LINES AND
AIR DUCTS ARE FIXED WITHIN TOLERANCES OF $\pm 2\text{mm}$.

Figure 3.2 - 20b: Air Duct and Fire Suppression Line Location - Double Rack

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* CABLE TIE STRUTS USED FOR FIRE SUPPRESSION LINES AND AIR DUCTS ARE FIXED WITHIN TOLERANCES OF $\pm 2\text{mm}$.

Figure 3.2 - 21: Air Duct and Fire Suppression Line Location - Single Rack

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3.2.3.1.2 Air Duct Segmentation

The air duct configuration can be modified according to user requirements because the air ducts are segmented as shown in Figure 3.2 - 22 and 3.2 - 23.

All upper air duct segments which are not used can be removed. The covers to close the residual ducting are provided by Spacelab.

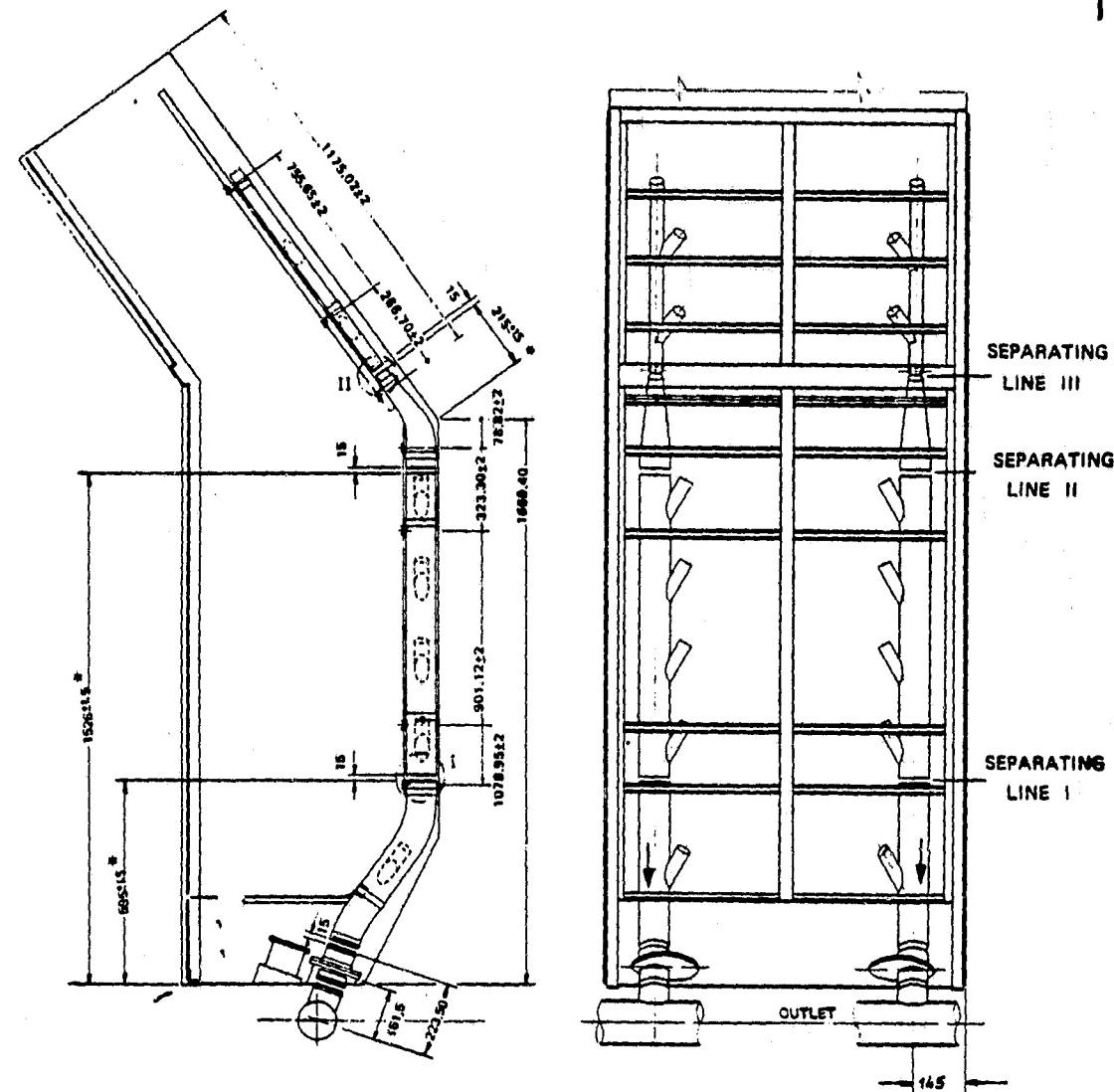
Detail of the air duct segment joints are given in Figure 3.2 - 22.

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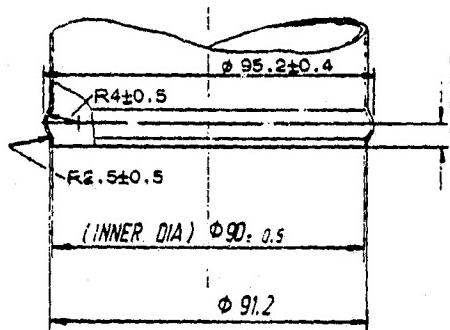
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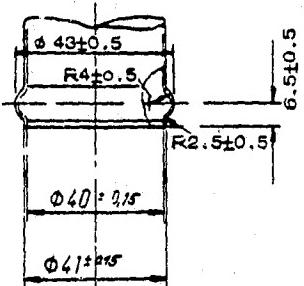
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DETAIL I

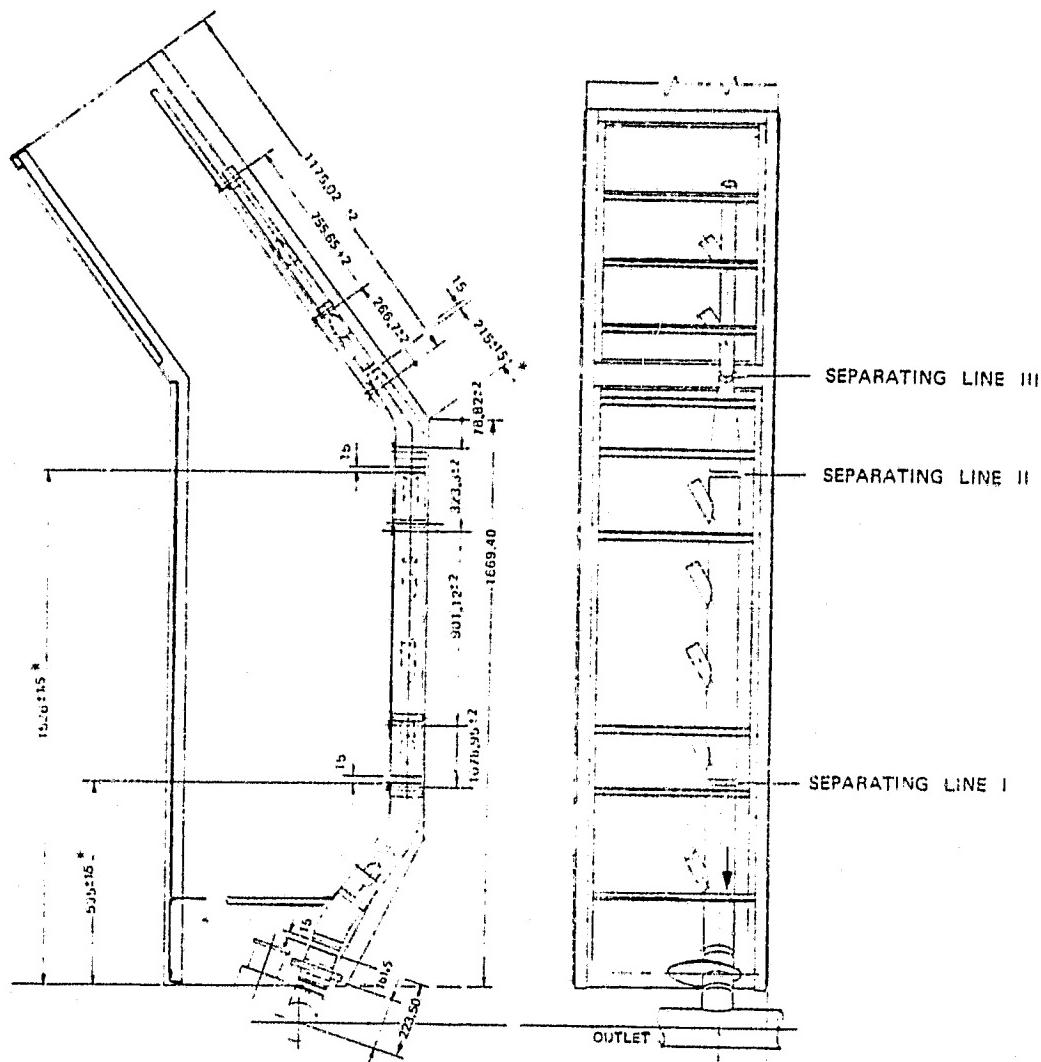


DETAIL II



* LOCATION OF DUCT SEPARATION
(SEE ALSO FIG. 3.2-22c)

Figure 3.2 - 22a: Air Duct Disconnection Points - Double Rack



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* LOCATION OF DUCT SEPARATION ISEE ALSO FIG. 3.2-22c

Figure 3.2 - 22b: Air Duct Disconnection Points - Single Rack

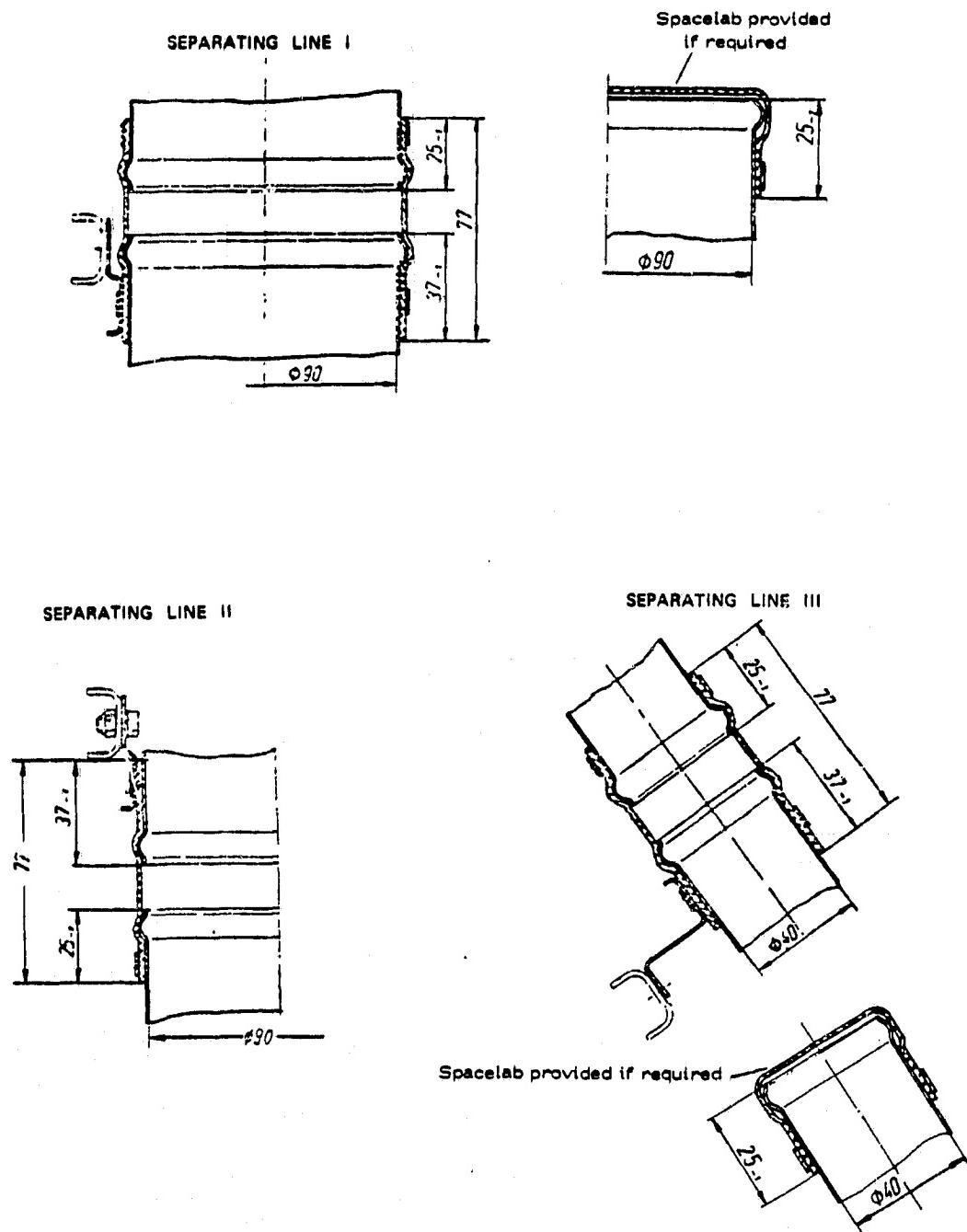


Figure 3.2 - 22c: Air Duct Segment Joints

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3.2.3.1.3 Rack Shut-Off Valves

The location of the shut-off valves in the bottom of the experiment racks is given in Figure 3.6 - 23/24. The drawing shows which parts of the bottom area of the rack are occupied by shut-off valves and air-ducting and thus not available for utility routing.

If no air cooling at all is required all air ducting and the shut-off valves can be removed. The holes for the air ducts in the bottom of the rack are then closed out by Spacelab provided blind panels as shown in Figure 3.1 - 24.5.

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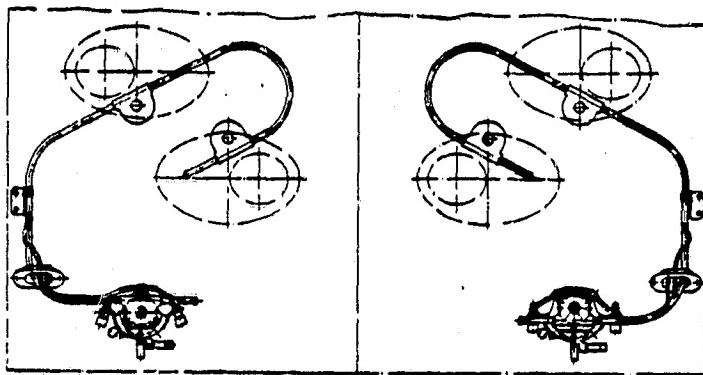


Figure 3.2 - 23a: Shut off valve in Double Rack

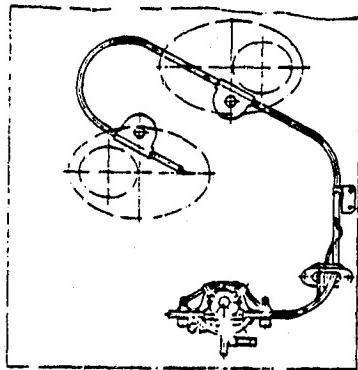


Figure 3.2 - 23b: Shut off valve in Single Rack

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B 3.2 - 72

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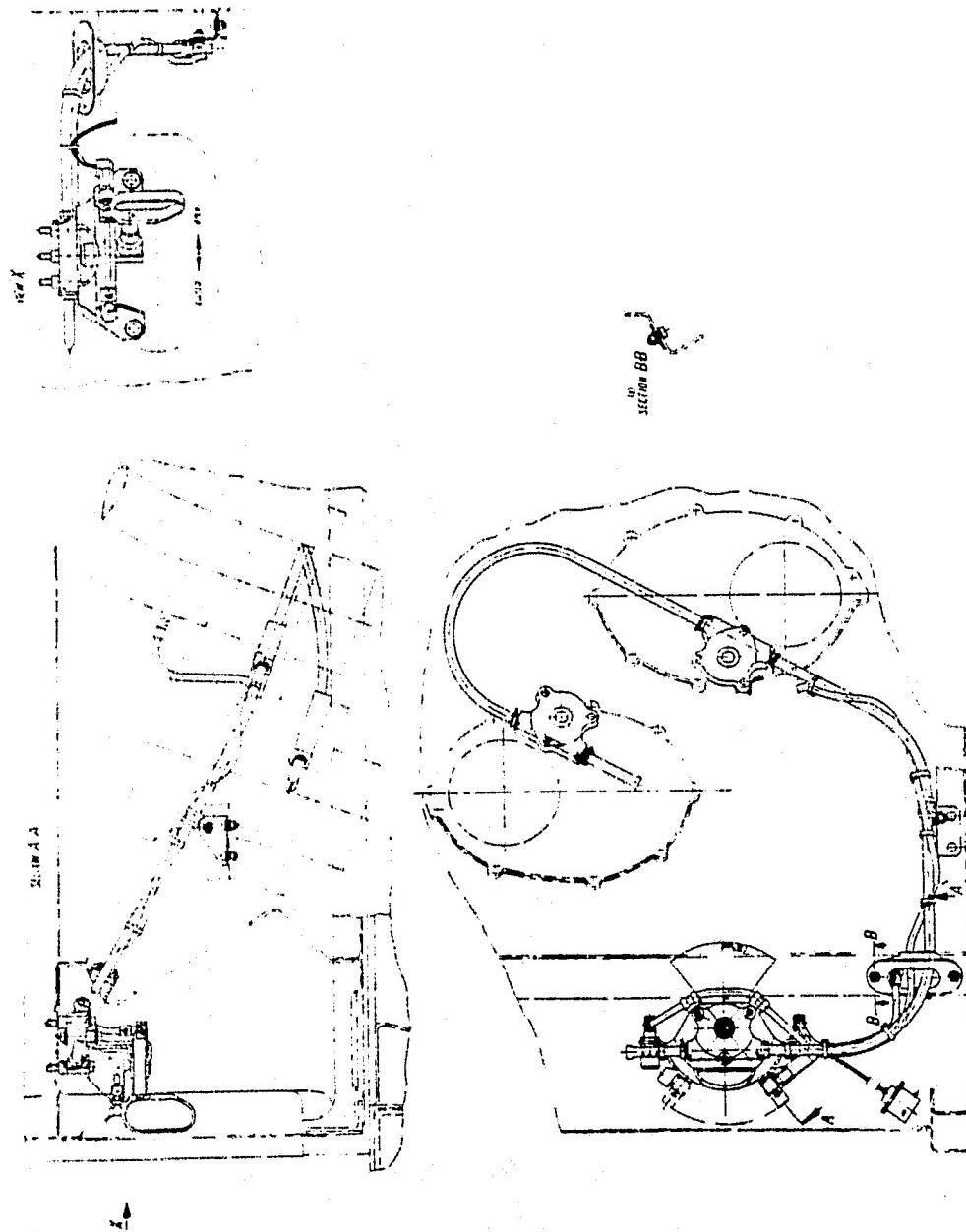


Figure 3.2 - 23c: Shut off valve Assembly

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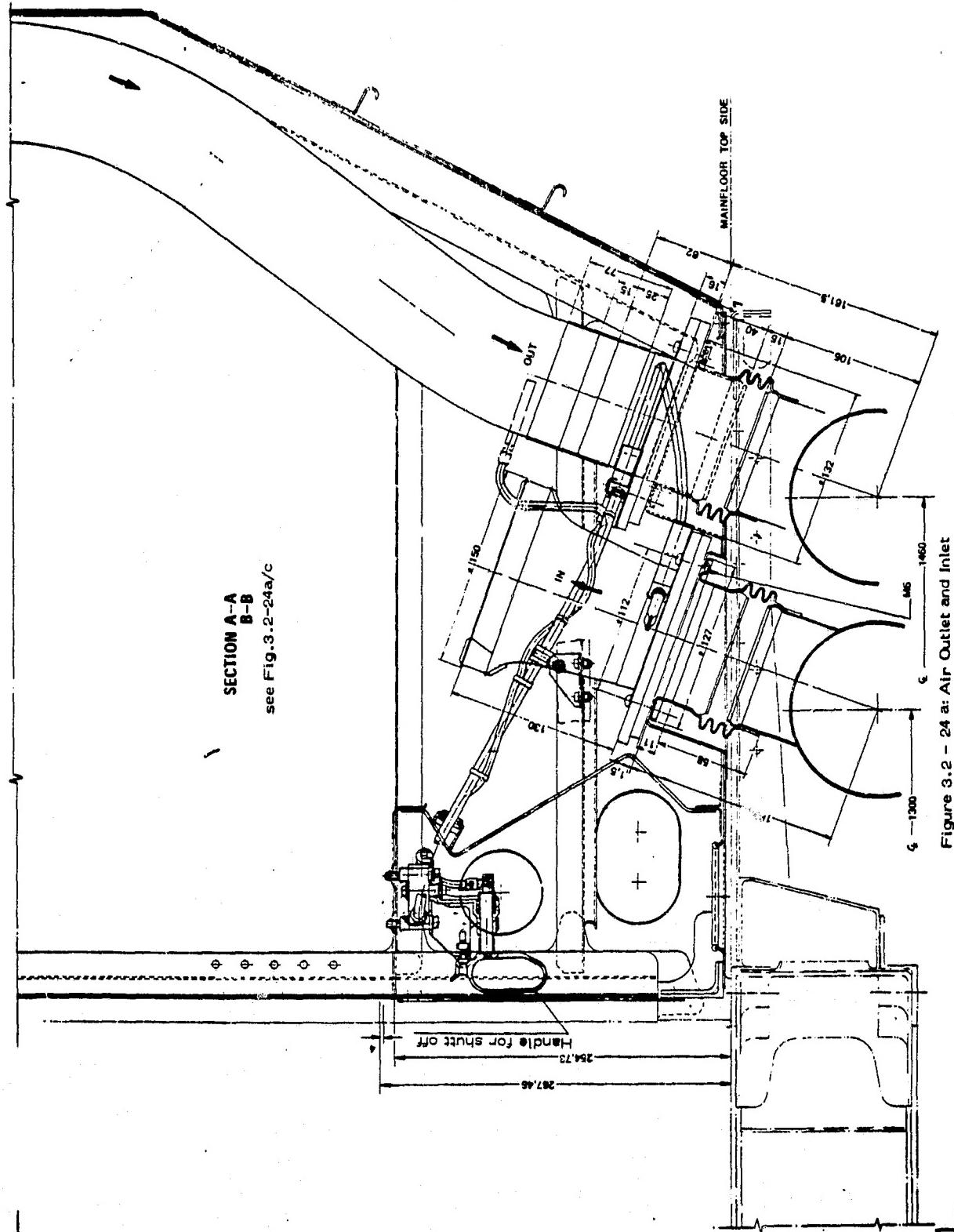


Figure 3.2 – 24 a: Air Outlet and Inlet

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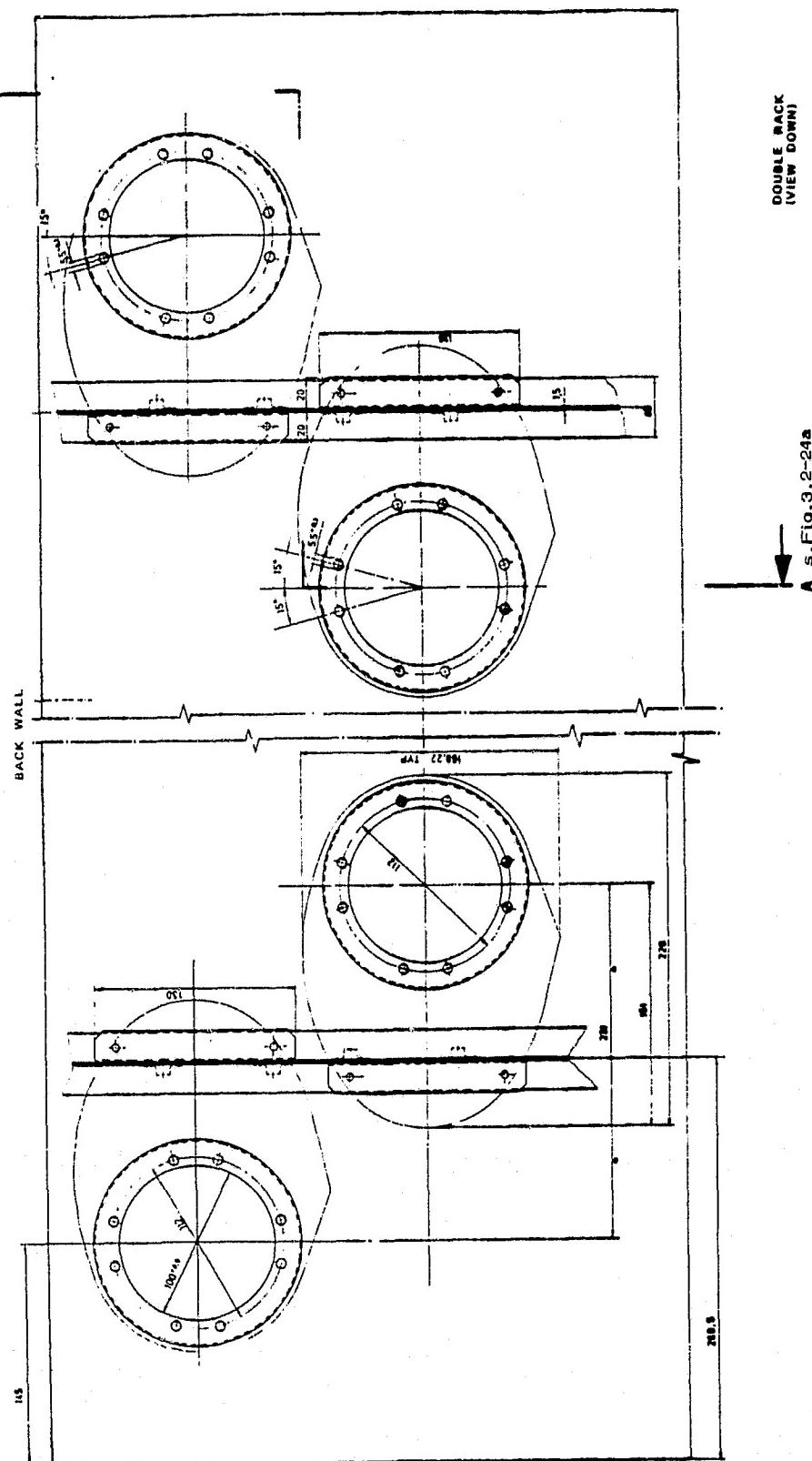


Figure 3.2 - 24 b: Locations of Shut-Off Valves - Double Rack

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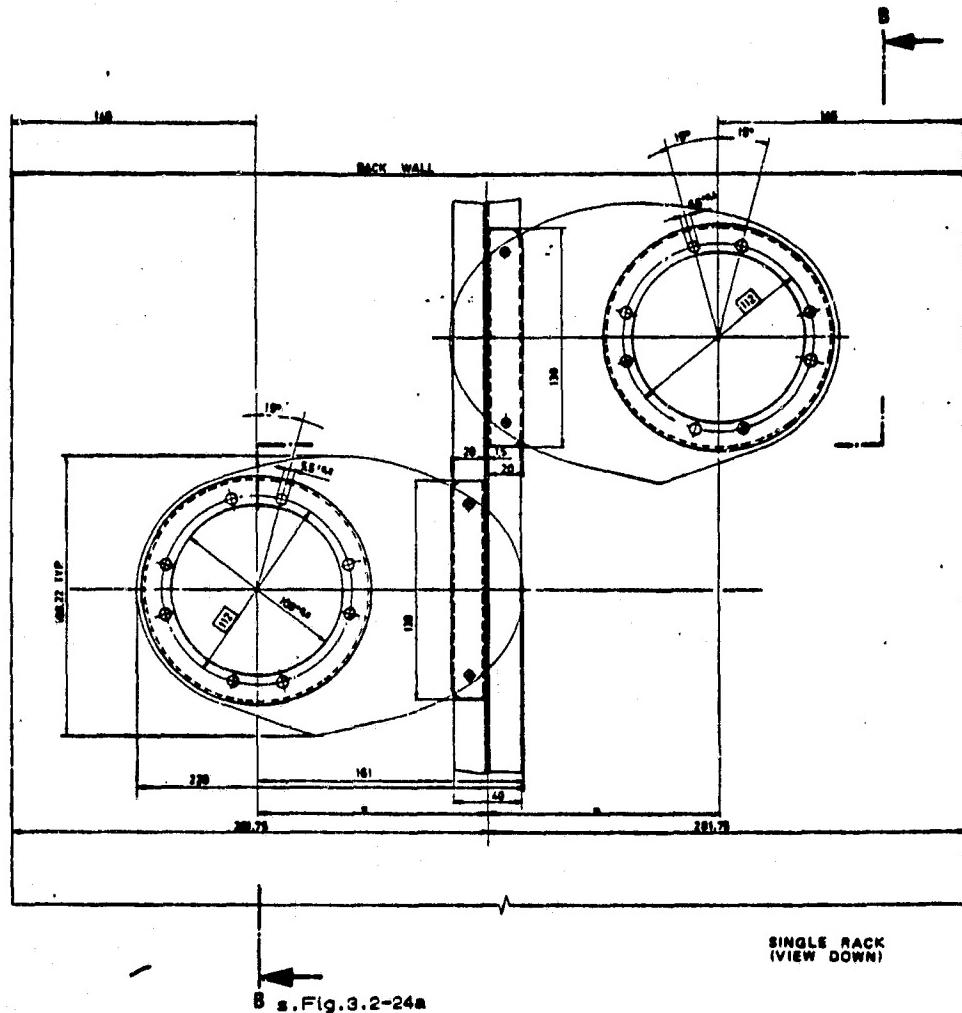
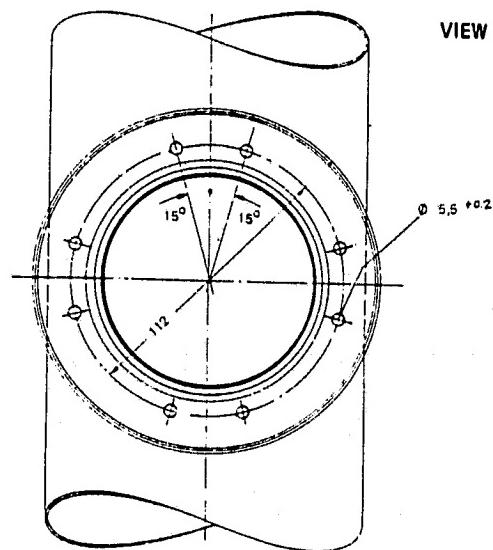
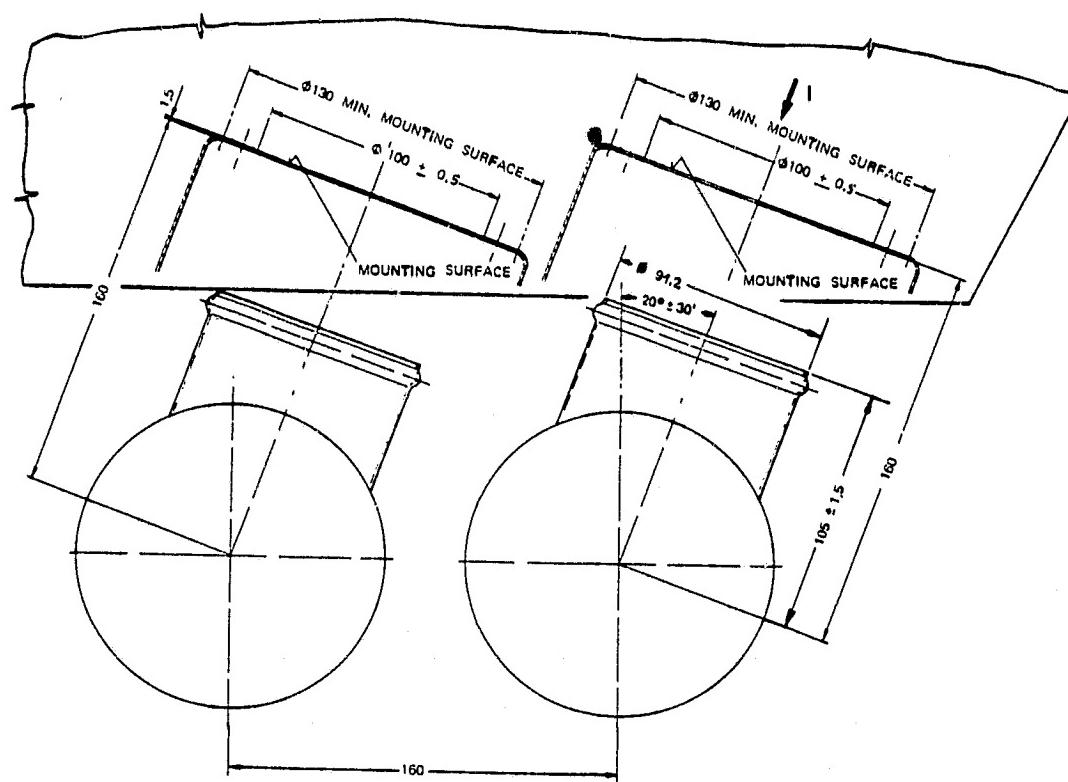


Figure 3.2 - 24 c: Locations of Shut-Off Valves - Single Rack

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Figure 3.2 - 24d: Air Duct Blind Panel Interface

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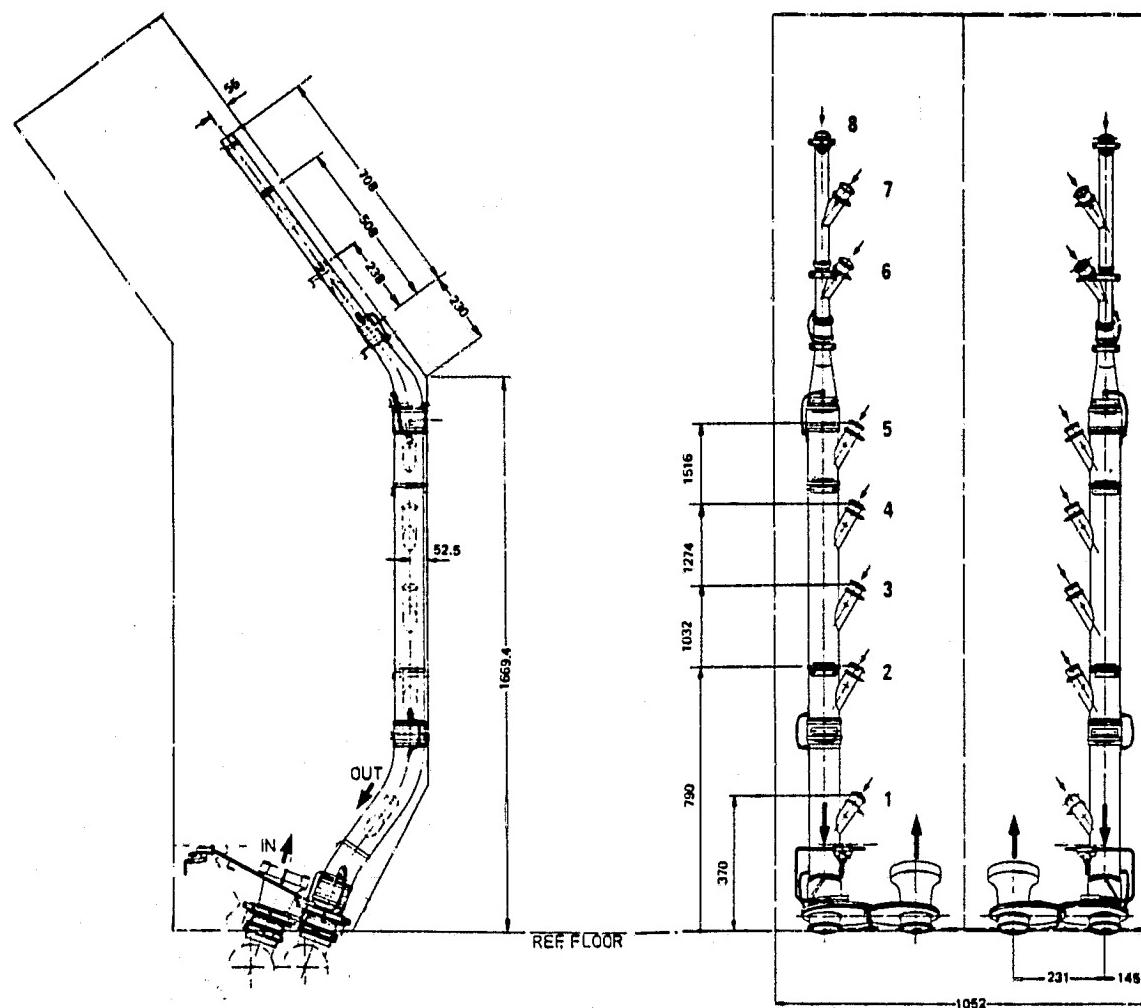
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3.2.3.1.4 Air Duct Experiment Interface

Each rack air duct pipe has 8 stubs which contain adjustable butterfly valves for the setting of the air flow rate. The location of the stubs are given in Figure 3.2 - 25.

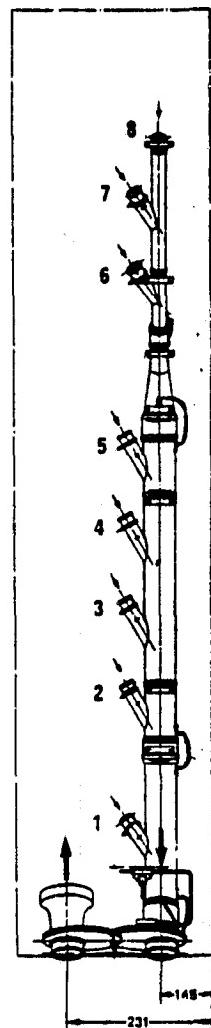
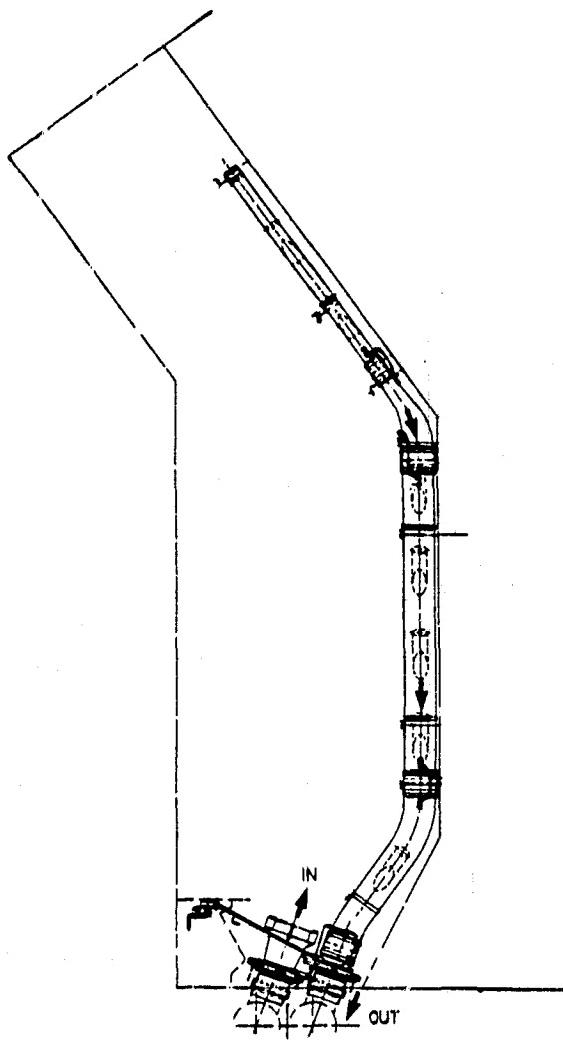
Experiment equipment which employs ducted air cooling interfaces directly with these stubs.

The details of this interface are shown in Figure 3.2 - 25



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Figure 3.2 - 25a: Duct Details - Overview Double Rack



Locations of Stubs see Fig.3.2-25a

Figure 3.2 - 25b; Duct Details - Overview Single Rack

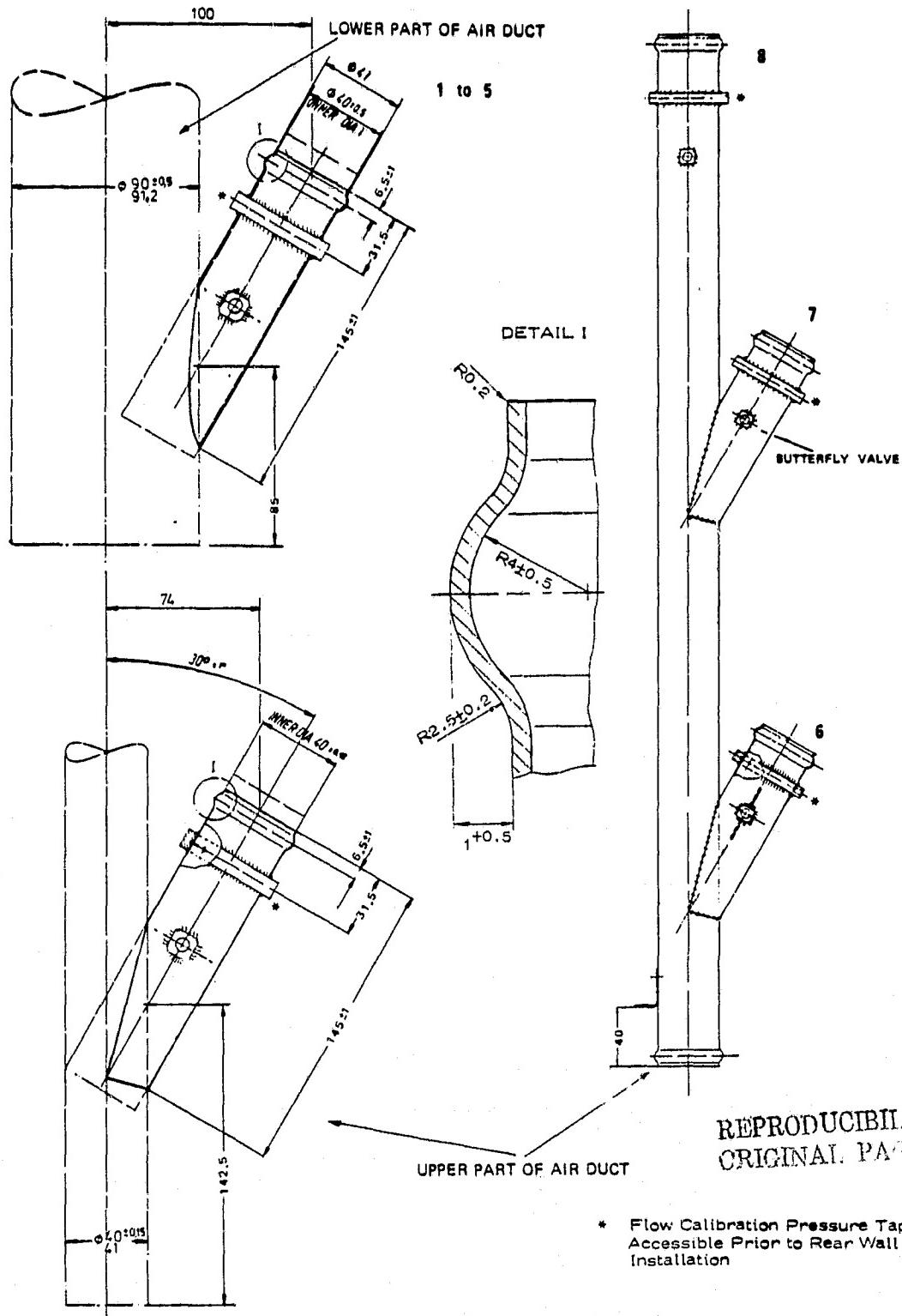


Figure 3.2 - 25c; Stub Dimensions

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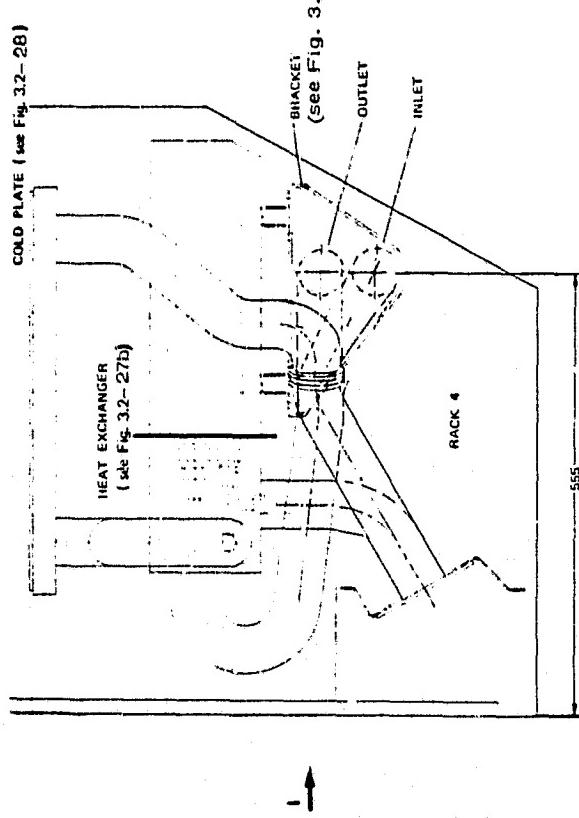
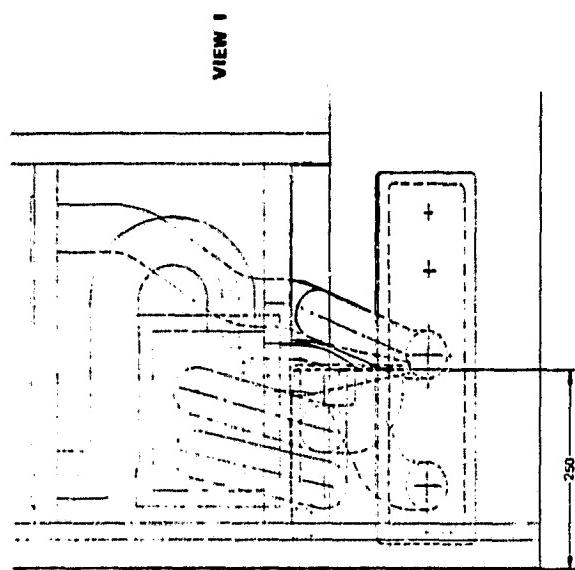
3.2.3.2 Experiment Heat Exchanger

3.2.3.2.1 Rack 4 Configurations

Rack 4 can be equipped with

- the experiment heat exchanger and the module experiment cold plate
(see Figure 3.2 - 26a)
- the experiment heat exchanger only (see Figure 3.2 - 26b)
- the module experiment cold plate only (see Figure 3.2 - 26c)

Whenever the heat exchanger or the cold plate is installed there is no air duct in the left side of rack 4.



NOTE: Further dimensions are still T B D.

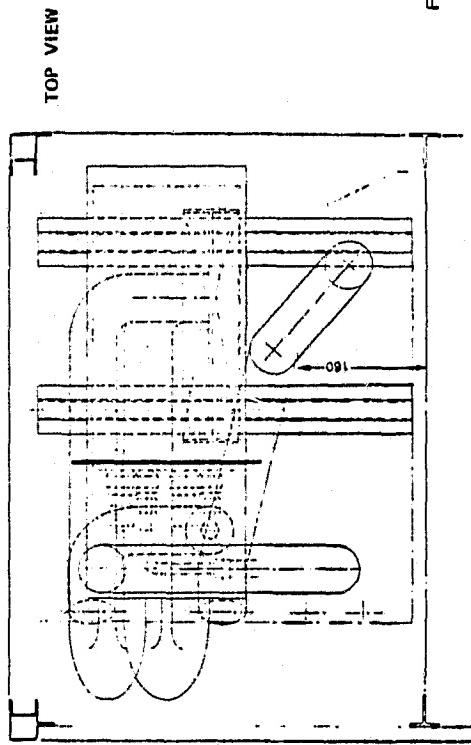


Figure 3.2 - 26a : Rack 4, Heat Exchanger / Coldplate Configuration

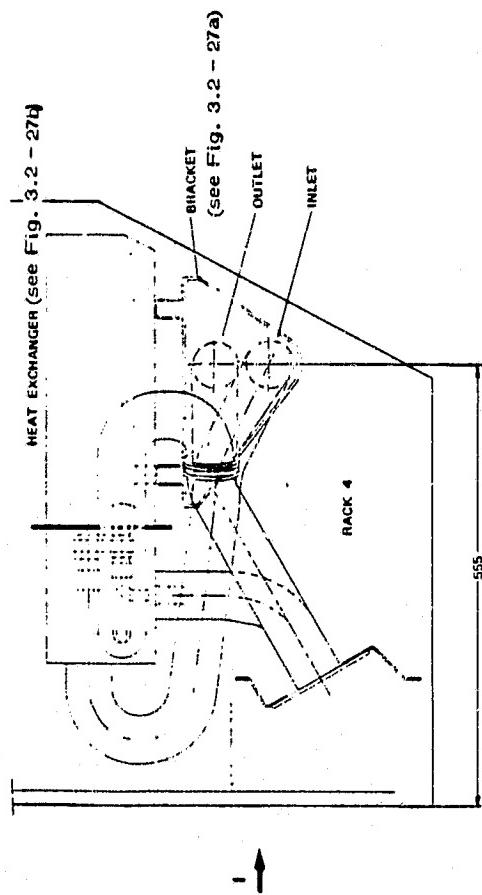
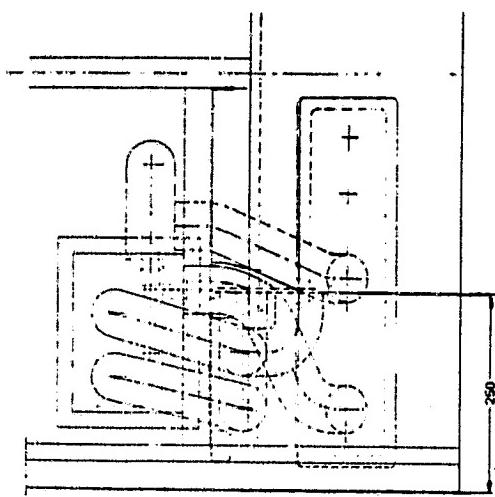
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NOTE: Further dimensions are still T B D.

TOP VIEW

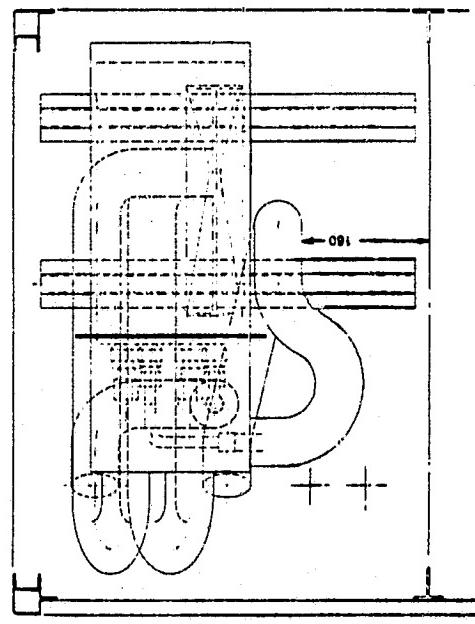
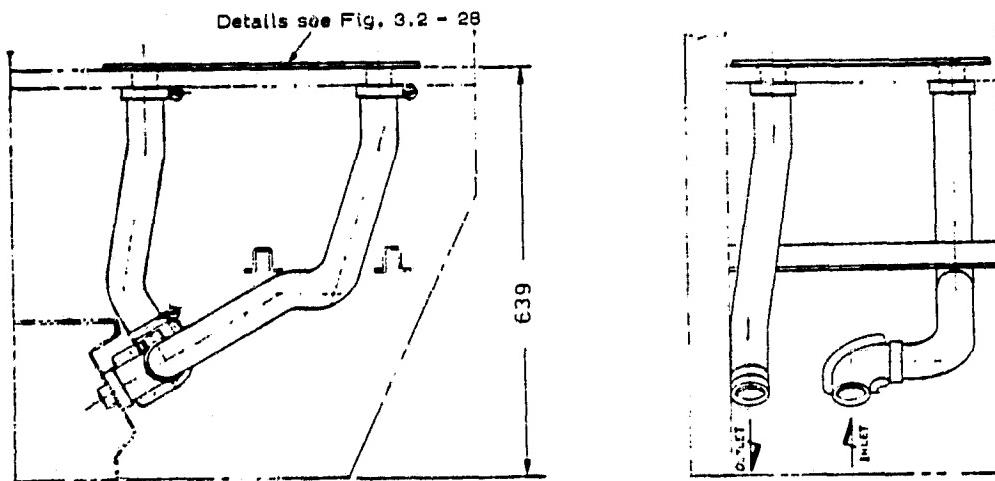


Figure 3.2 - 26b : Rack 4, Heat Exchanger Configuration

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NOTE: Further dimensions are still T B D.

Figure 3.2 - 26c: Rack 4, Coldplate Configuration

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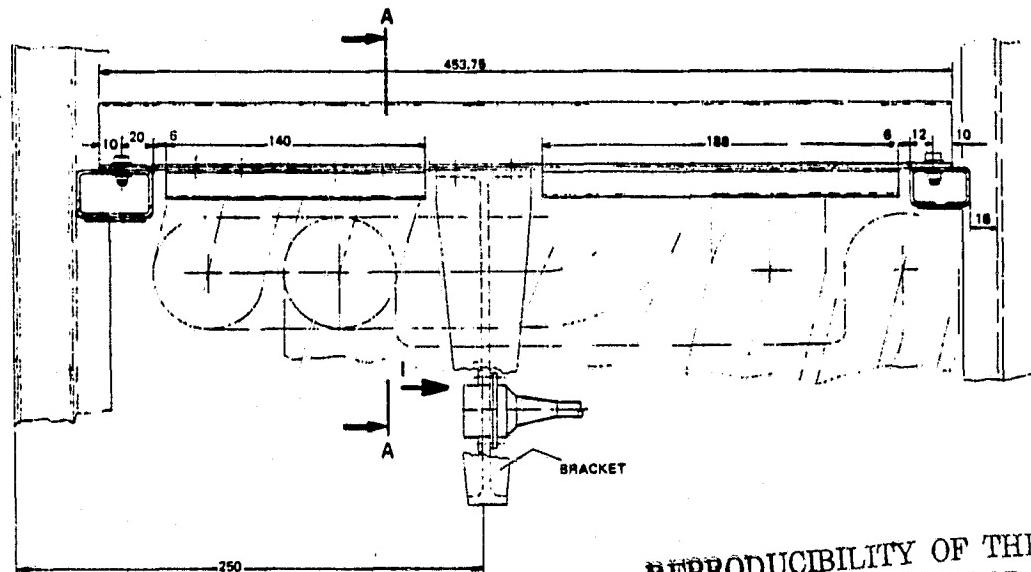
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3.2.3.2.2 Experiment Heat Exchanger Interface

The experiment interface to the experiment heat exchanger, i.e. the interface for the secondary liquid loop, is at a bracket underneath the heat exchanger support structure. Details are given in Figure 3.2 - 27.

Possible routing concepts for the user provided secondary liquid loop are given in section 3.9.3.



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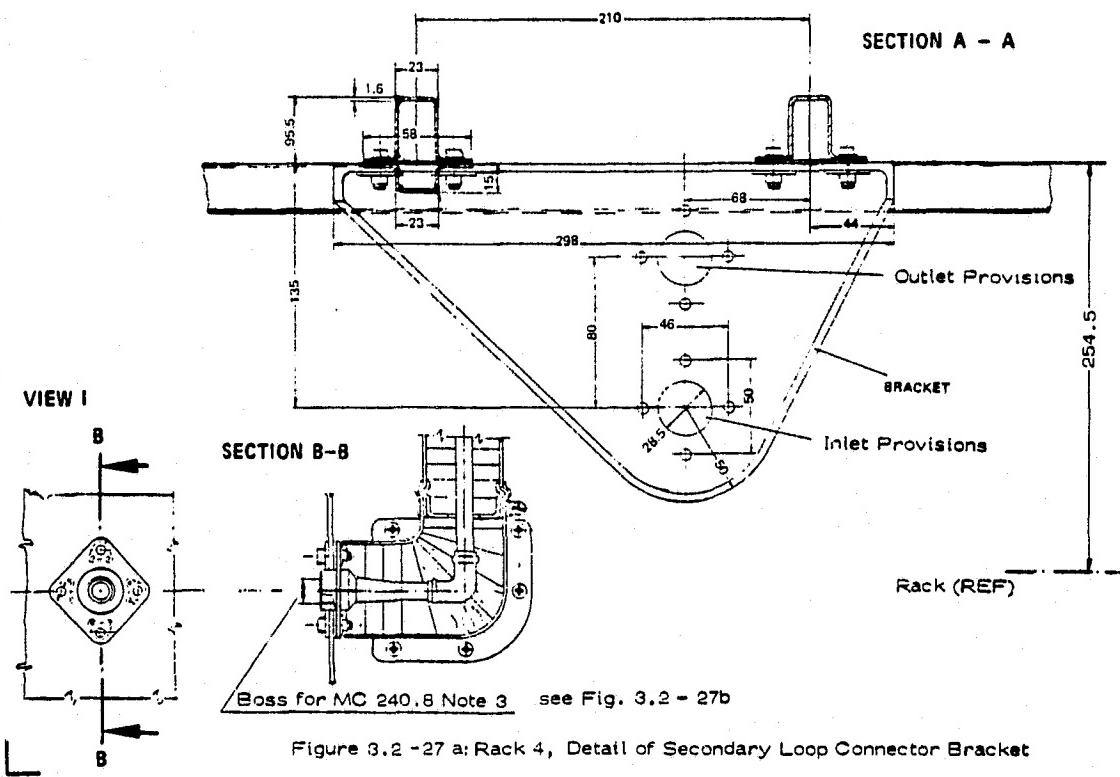
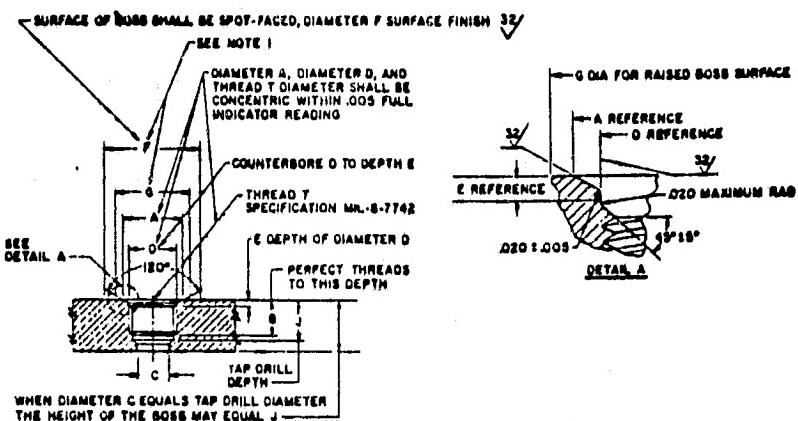


Figure 3.2 - 27 a: Rack 4, Detail of Secondary Loop Connector Bracket



Equivalent Tube Size Dash No	Tubing OD	Thread T	A +.015 -.000 Dia.	B Min.	C Min. Dia.	D +.005 -.000 Dia.	E +.015 -.000	F Min. Dia.	G Min. Dia.	J Min.
8	1/2	3/4-16 UNF-2B	.875	.562	.391	.769	.094	1.188	1.032	.718

Note 3 : Dimensions in Inches Unless otherwise Specified, Tolerances: Angles + 1/2°

Figure 3.2 - 27b : Boss, Standard Dimensions for Straight Thread (MC 240)

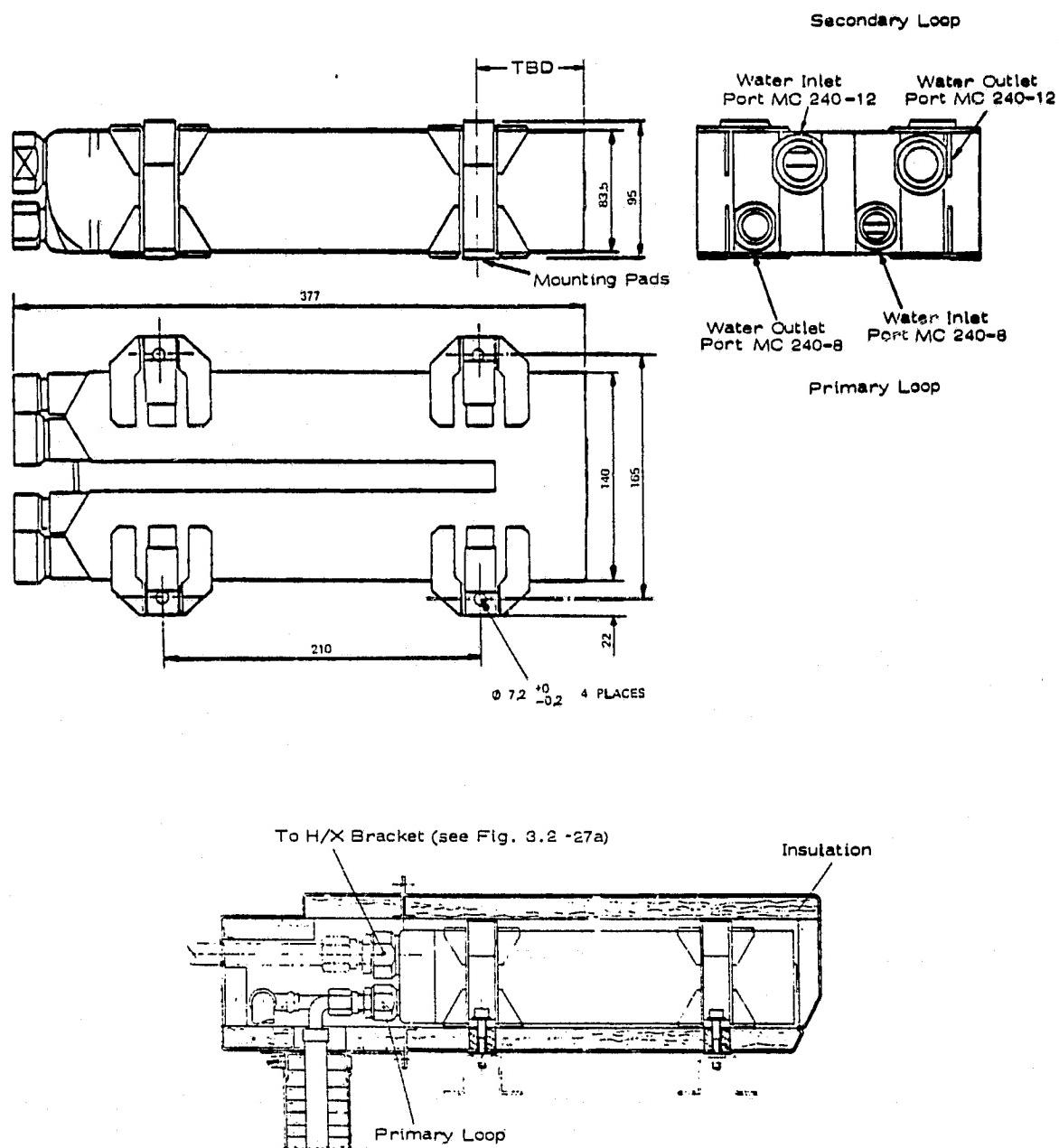


Figure 3.2 - 27c : Experiment Dedicated Heat Exchanger in Rack 4

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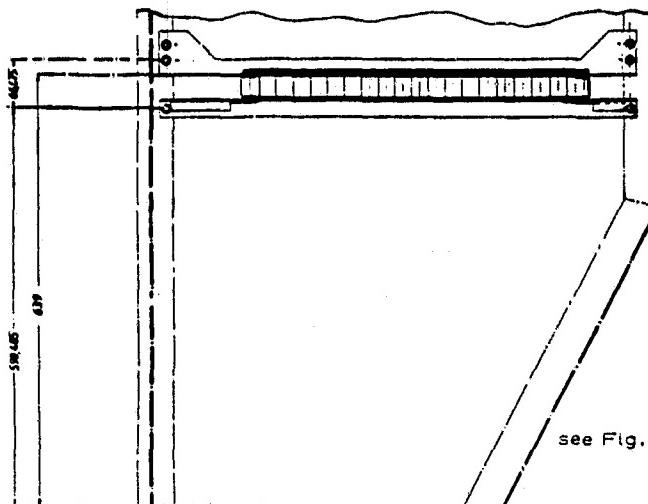
3.2.3.2.3 Module Experiment Cold Plate

The mechanical interface of the module experiment cold plate is shown in Figure 3.2 - 28 .

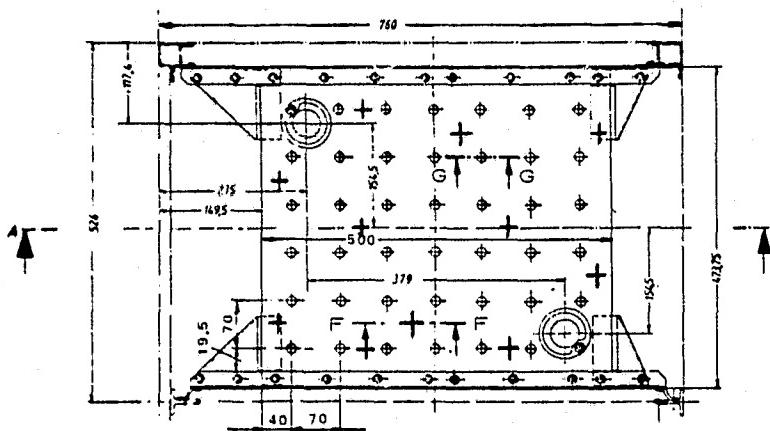
The experiment interface requirements are TBD.

The overall load carrying capability is 30 kg. C.g. constraints and local limit loads are TBD.

SECTION A-A

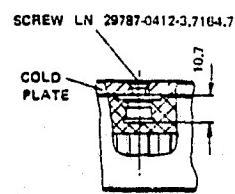


see Fig. 3.2-26a

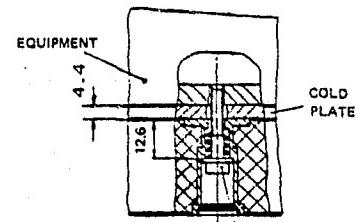


SECTION G-G

SECTION F-F



Cold Plate Tie Down



SCREW LN 29950-0525-3.7164.7
WASHER LN 9025-6.3-3.1364.5

Experiment Attachment

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Figure 3.2 - 28: Experiment Dedicated Cold Plate in Rack 4

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3.2.4 EPDS/CDMS Interface

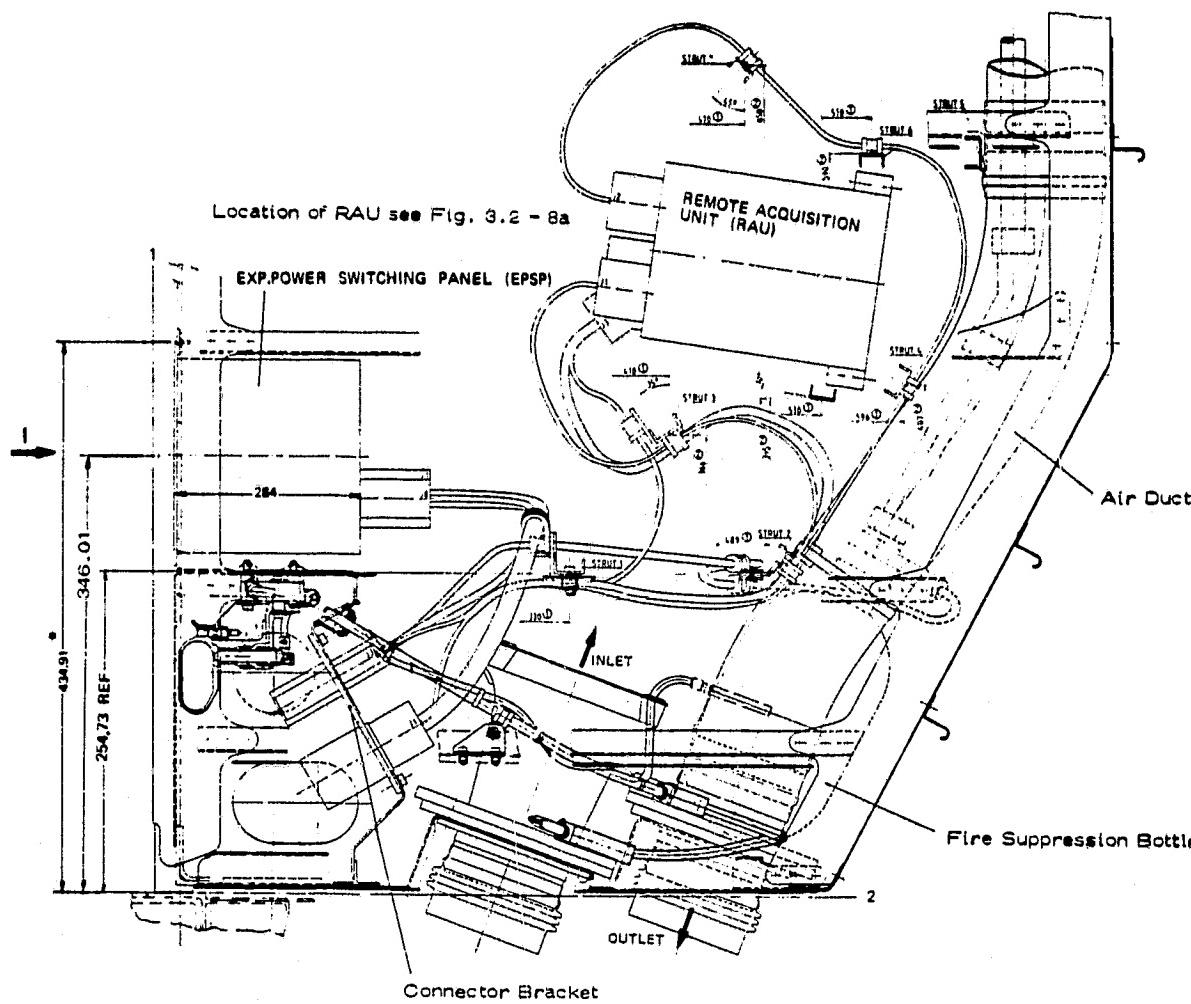
The EPDS and CDMS interface for experiment equipment in a rack is at the boxes EPSP and RAU directly, which are located in the racks as shown in Figure 3.2 - 29. The mechanical details of EPSP and RAU are given in Figure 3.2 - 30 and 3.2 - 31.

The electrical interface to EPSP and RAU is defined in Appendix A, section 3.2 and 4.1.

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Figure 3.2 - 29a: Detailed Overview of Lower Rack Equipment - Side View

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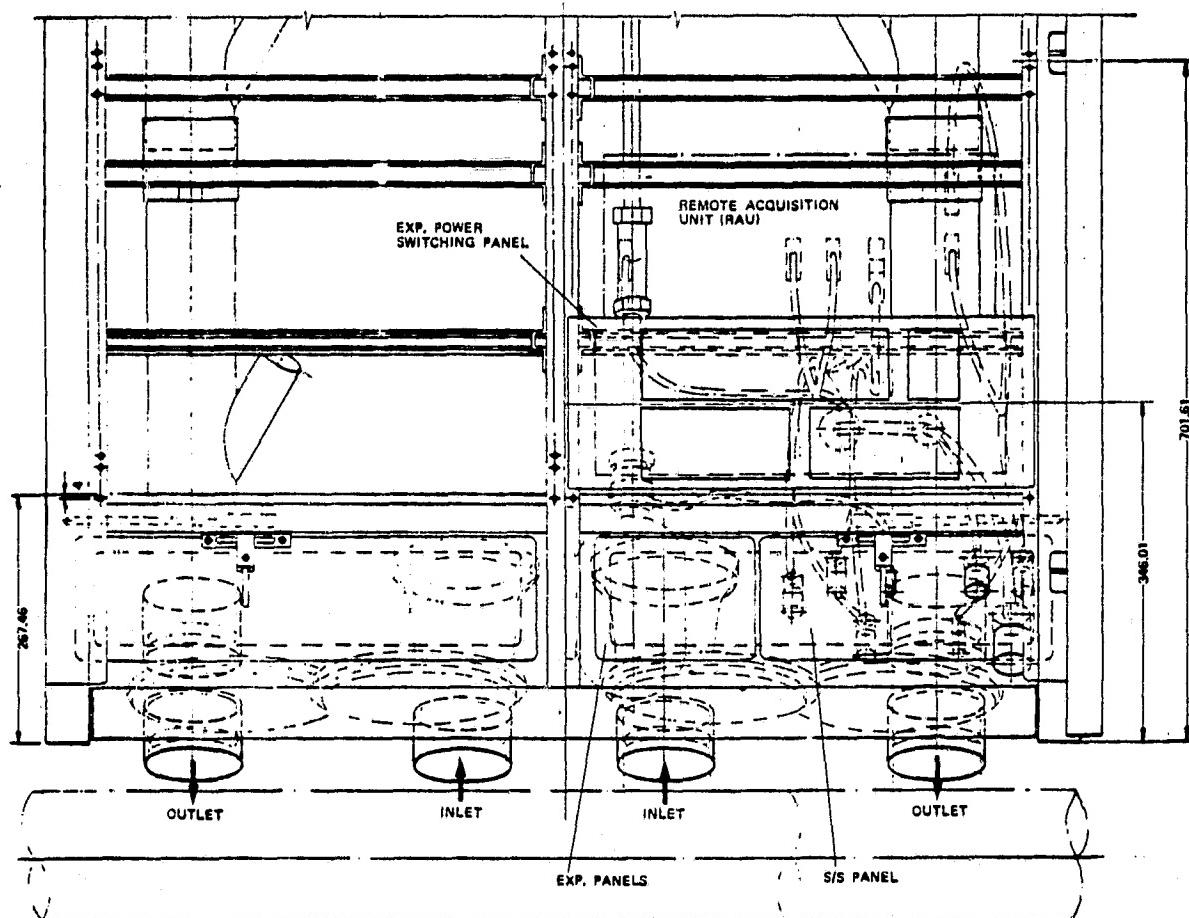
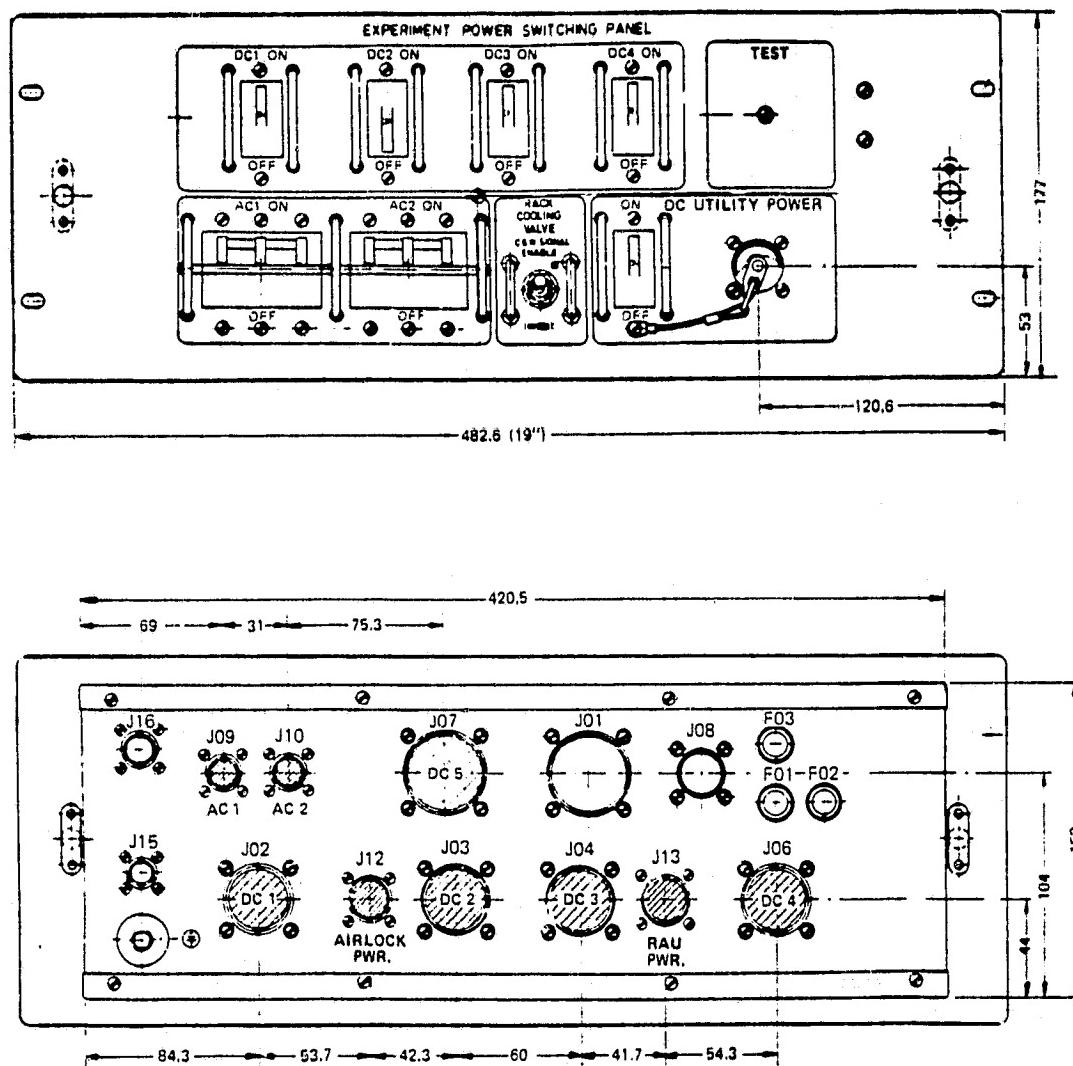


Figure 3.2 - 29b: Detailed Overview of Lower Rack Equipment - Front View

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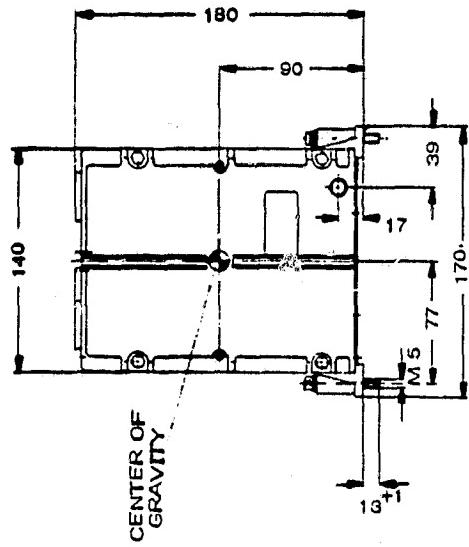
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Figure 3.2 - 30: Experiment Power Switching Panel (EPSP)



RAU connector location is
given in Fig. 4.1-1 of App. A

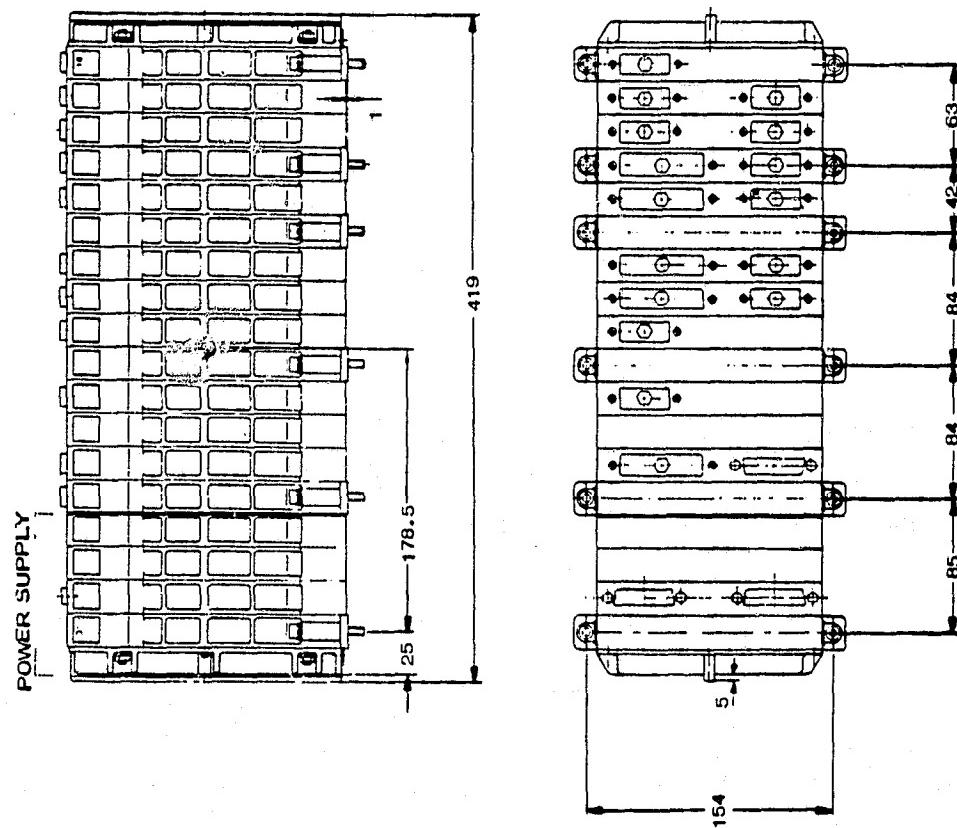


Figure 3.2 - 31: Dimensions of Remote Acquisition Unit (RAU)

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3.2.5 Rack Utility Routing Provisions

3.2.5.1 Rack to Main Floor Routing

The concept of routing experiment utilities from the rack to the main floor is shown in Figure 3.2 - 32

The utilities have to be routed through

- the experiment dedicated connector panels (see Figure 3.2 - 32)
- the rack bottom holes (see Figure 3.2 - 32)
- the holes in the outer main floor beams to the volumes under the main floor dedicated to experiment utilities (see section 3.9.1).

The operational break between rack and main floor is at the connector panels, i.e. rack utilities will end in receptacles mounted to the panels, main floor utilities will end in loose connectors.

The connector panels at the bottom of the racks as shown in Figure 3.2 - 32b consist of

• Subsystem Panels

The subsystem connector brackets do not represent an experiment interface. However, for information panel layout and connector functions are given.

Connector Functions at Rack Bottom Connector Bracket

- J 1 DC to EPSP
- J 2 AC to EPSP
- J 3 Shut-off valve monitoring to RAU
- J 4 Shut-off valve monitoring to RAAB
- J 5 To fire suppression bottle
- J 6 AC to Airlock (rack 4 only)
- J 7 DC to Airlock
- J 8 Shut-off valve to EPSP
- J 10 RAU bus
- J 11 RAU bus
- J 12 RAU monitor and control
- J 13 Intercom (rack 4, 7, 10 only)

For functions not used blind panel instead of connector is installed.

This applies to

- J 6, J 7 for all double racks and for rack 4
if airlock is not flown
- J 10, J 11, J 12 if there is no RAU in that particular rack
- J 13 if there is no intercom remote station
in that particular rack

• Experiment Panels

The experiment dedicated panels are blank plates. These blank panels will be replaced on a mission to mission basis by experimenter provided panels equipped with connectors and fittings as required by the actual payload.

The experiment dedicated connector panels are identified by an alpha-numeric code which is explained in the following example:

Prefix which stands for Connector Bracket Rack — CBR 10 R
Number from 1 to 12 denoting the rack number —
Suffix denoting left (L) or right (R) side, used —
in case of double racks only —

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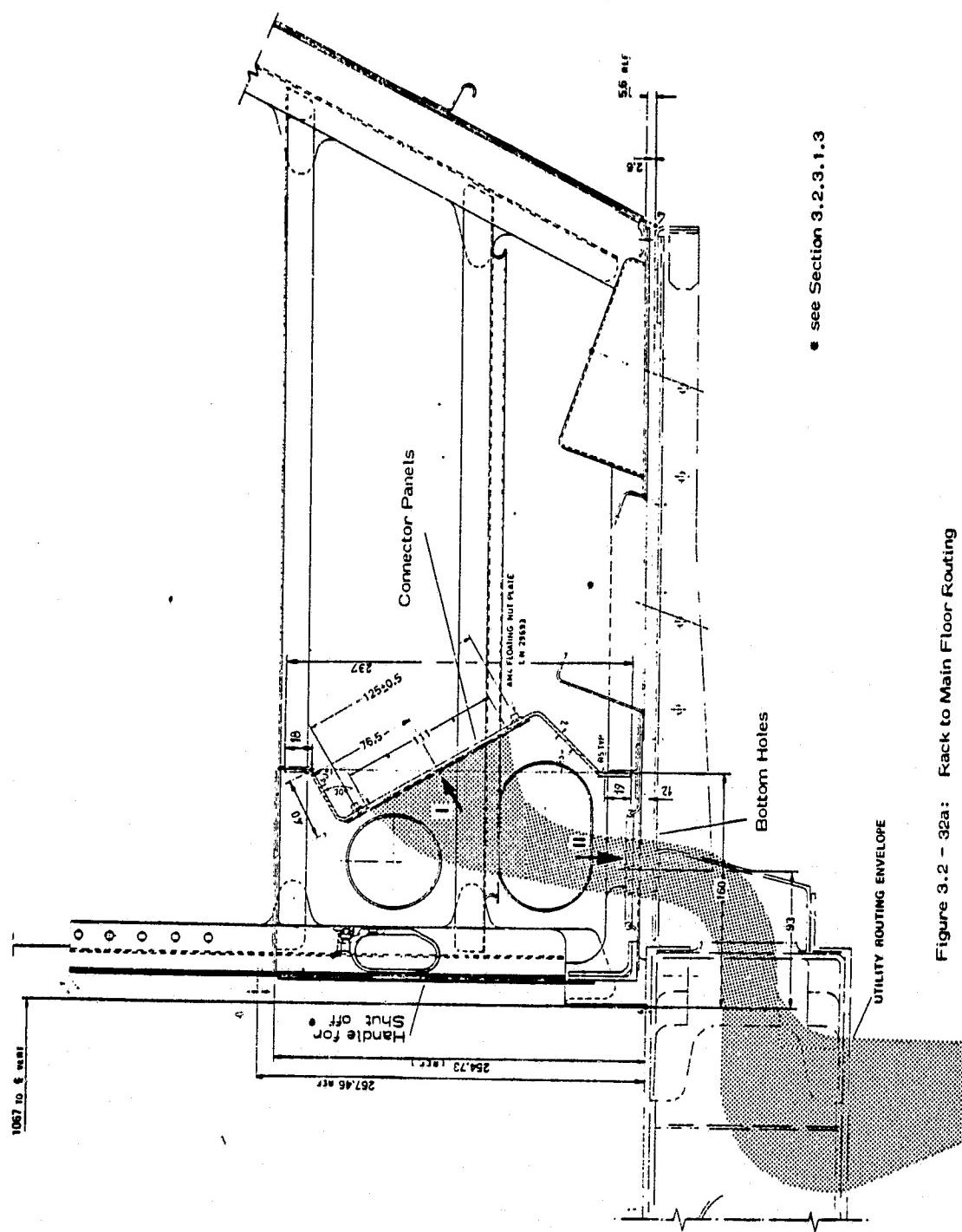
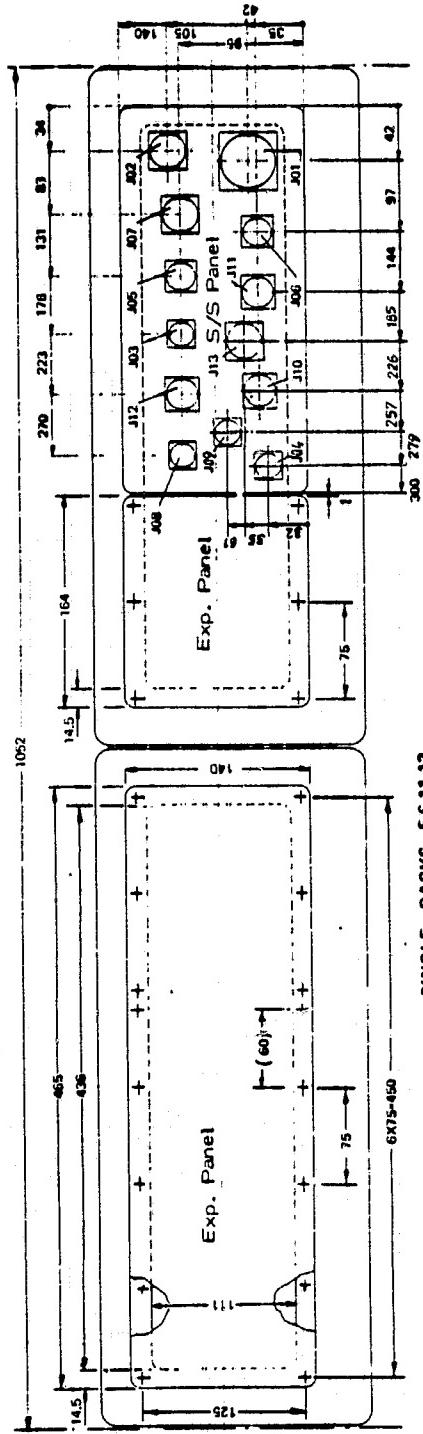


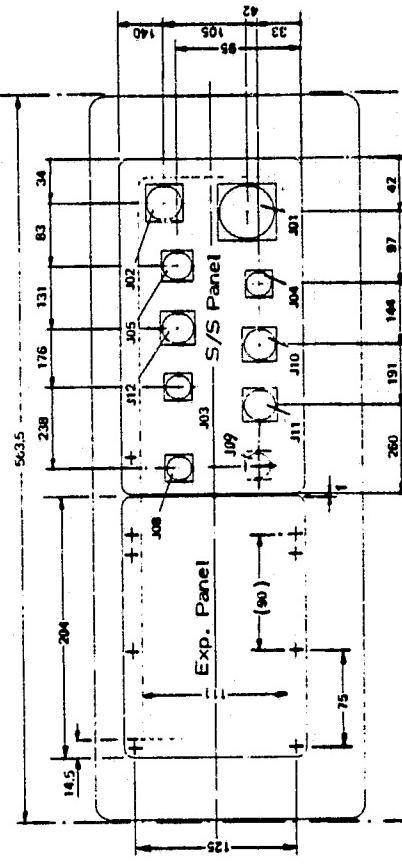
Figure 3.2 – 32a: Rack to Main Floor Routing

VIEW 1

DOUBLE RACKS 3,4,7,8,9,10



SINGLE RACKS 5,6,11,12



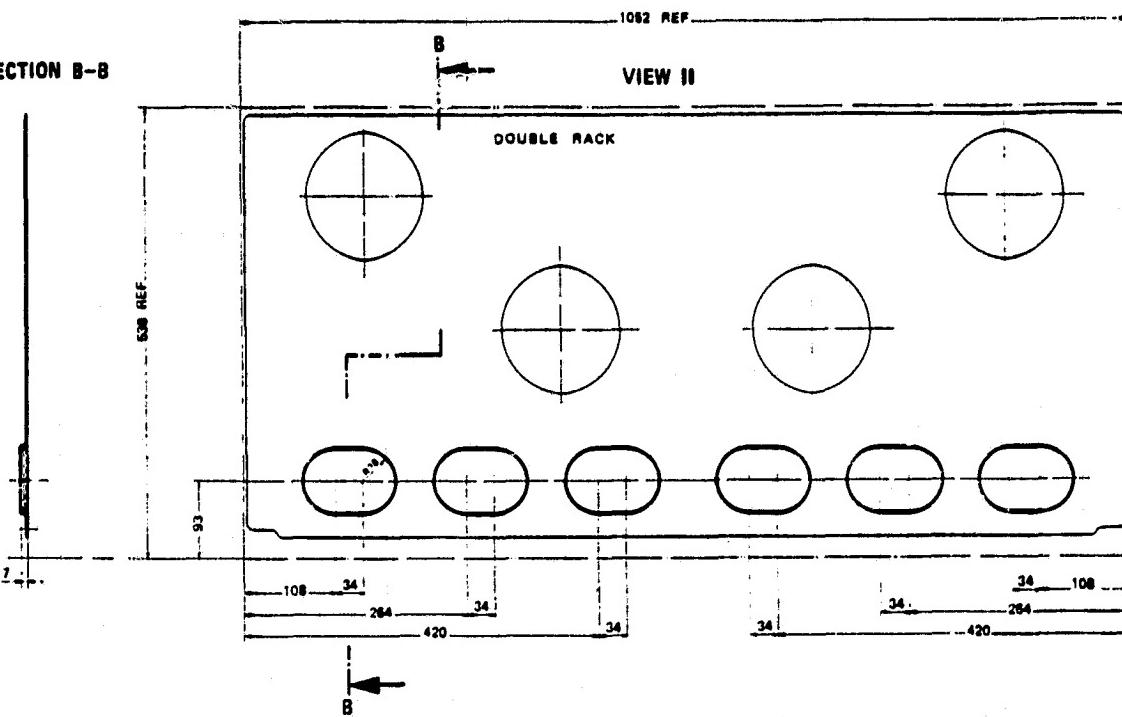
SECTION B-8

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VIEW II

B

DOUBLE RACK



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VIEW II

B

SINGLE RACK

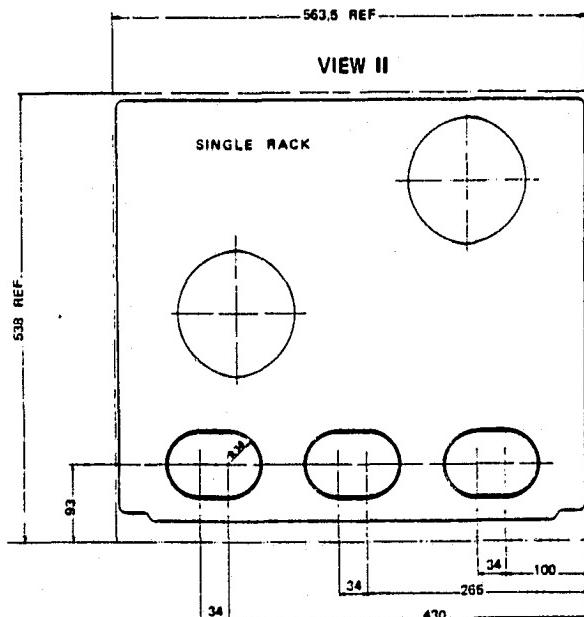


Figure 3.2 - 32c: Rack Bottom Holes

3.2.5.2 Rack to Rack Routing

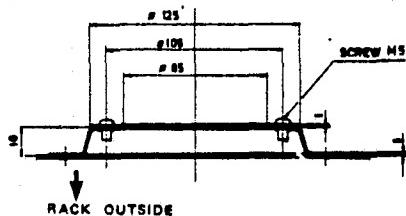
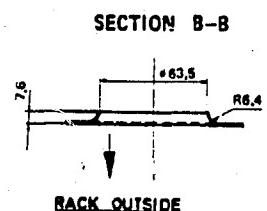
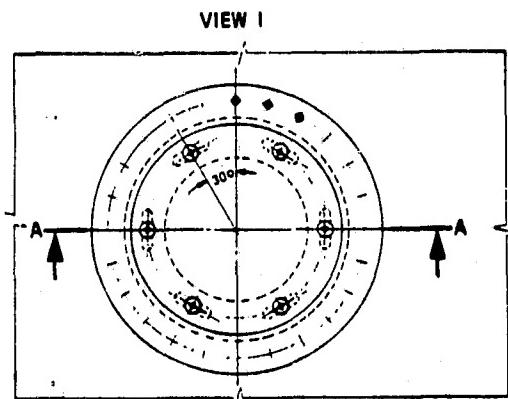
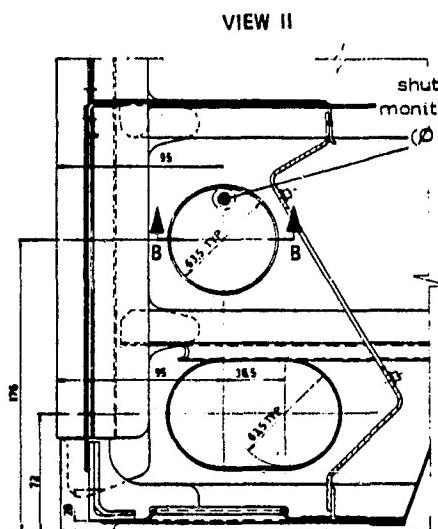
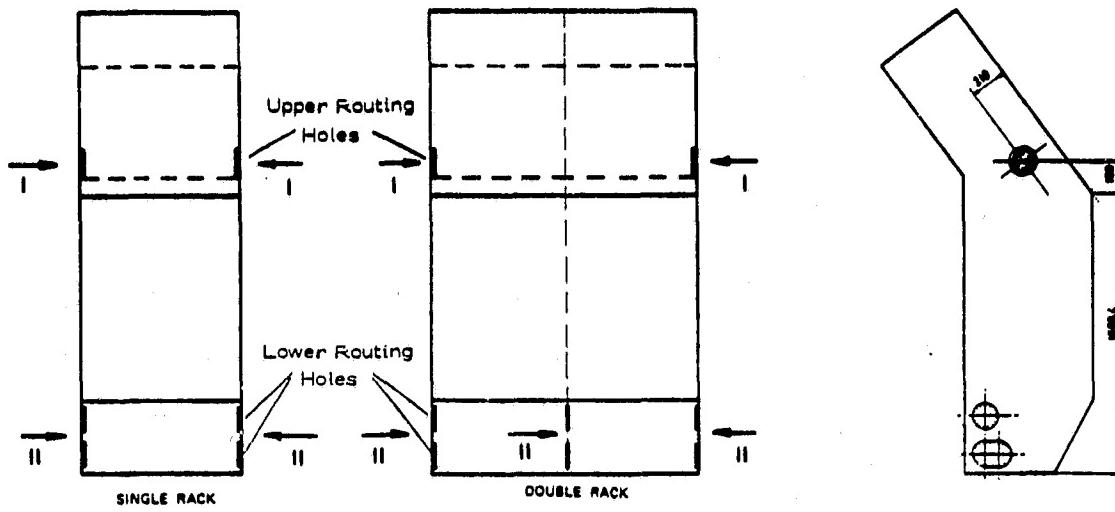


Figure 3.2 - 33 : Rack to Rack Utility Routing Holes

3.2.6 Rack Load Carrying Capability

The dimensioning loads of the rack (para 3.2.7) are :

- (1) bracket loads for the local carrying capability. These loads are applicable for the equipments at the interface of the rack to the equipment (attachments). Equipments must be attached to the rack in such a manner that a "hard-mounted" fundamental frequency above 35 Hz is reached -
- (2) flight loads for the overall carrying capability.

The bracket loads and the flight loads can be independently determined because of the decoupling of the equipment frequencies from the overall rack frequencies, i.e. $f_0 > 35$ Hz for equipments and $f_0 > 15$ Hz for the rack.

For certain mass configurations, it is possible to have the following rack configurations (see Tables 3.2-2 and 3.2 - 3):

- double rack with lower center post and 4, 3, 2, 1 or 0 diagonal shear load struts, whereas the number of diagonals depends on the masses to be accommodated in the rack.
- double rack without lower center post with 2, 1, or 0 diagonal shear load struts; however, no suitable diagonals are Spacelab provided.
- single rack with 2, 1, or 0 diagonal shear load struts

For the accommodation of payload equipment in the racks, three types of integration are standardized as per para 3.2.6.2 :

- front mounted
- front mounted / back supported
- shelf mounted

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3.2.6.1 Overall Rack Load Carrying Capability

The load carrying capabilities quoted comprise payload and Spacelab mission dependent equipment (EPSP, RAU, ICRS etc.). Masses accommodated in experiment racks have to comply with the following constraints:

- The maximum allowable mass for the entire rack is

for double racks	580 kg total
	290 kg each side

for double racks, lower center wall removed TBD

for single racks	290 kg
------------------	--------

These values apply only as long as the c.g.'s of the accommodated masses are within the envelopes given in Figures 3.2 - 34 a,b. For c.g.'s outside these envelopes, the maximum allowable masses will decrease and case-by-case analyses will be required.

- The maximum allowable mass for the upper part of the rack is 72.5 kg for single racks and each side of double racks

The allowable mass for the lower part of the rack depends on the number and locations of the shear load struts installed, and the mass distribution between the planes of the shear load struts. The allowable masses for the lower parts of the racks are given in Tables 3.2 - 2 and 3.2 - 3 as a function of these parameters.

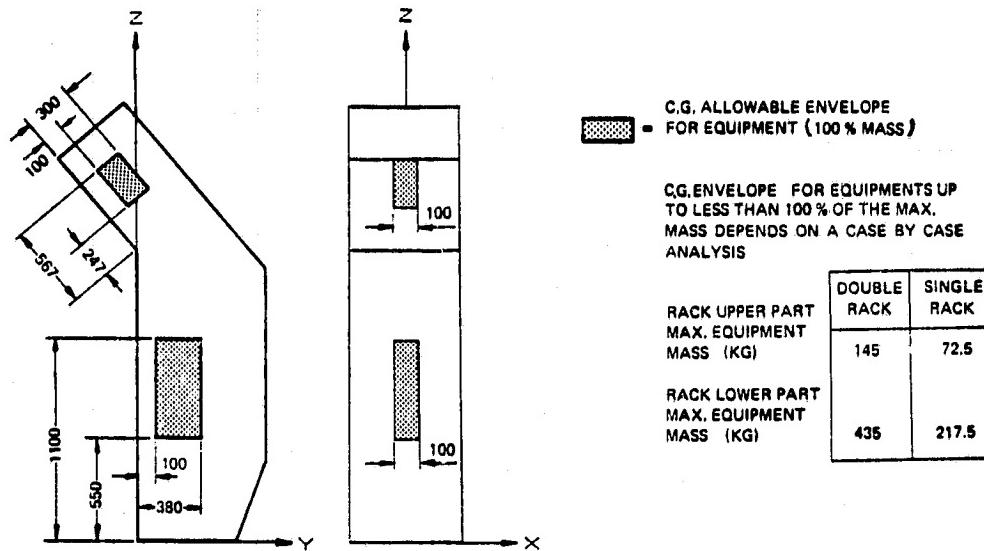


Figure 3.2 - 34 : C.G. Distribution Limitations for Single Rack and each Side of a Double Rack

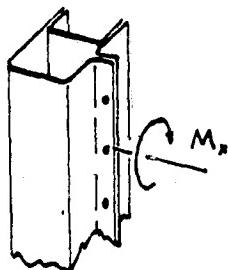
Critical items of the rack which limit the overall loading capability are:

- (1) Front side post : The limitation is given by $M_x + 10.9 F_z = 8.98 \times 10^5$

Whereas M_x = bending moment (Nmm)

F_z = axial force (N)

see Figure 3.2 - 34a for direction of forces



- (2) Diagonal shear load strut : Max axial force $T = 12370$ N

- (3) Upper center post attachment (double rack): $R_x = 13930$ N

The loads quoted represent the allowable limit loads.

The overall load carrying capability of a single rack is equal to the one of either side of a double rack. Each side of a double rack can be independently analyzed, since the interaction between both sides is minor. For instance, one side may have 2 diagonal struts while the other may have only one or zero, depending on the masses to be accommodated in the rack. On the other hand, one may not expect the maximum load carrying capability of 267 kg for one side of the lower part with only one diagonal strut installed.

Four cases are subsequently taken under consideration :

- Case 1 : 2 diagonal shear load struts in the lower part of the rack
- Case 2 : 1 diagonal shear load strut in the lower part of the rack
- Case 3 : No diagonal shear load strut installed
- Case 4 : Center wall removed in the lower part of a double rack

Case 1 : Two diagonal shear load struts in the lower part of a single rack or either side of a double rack

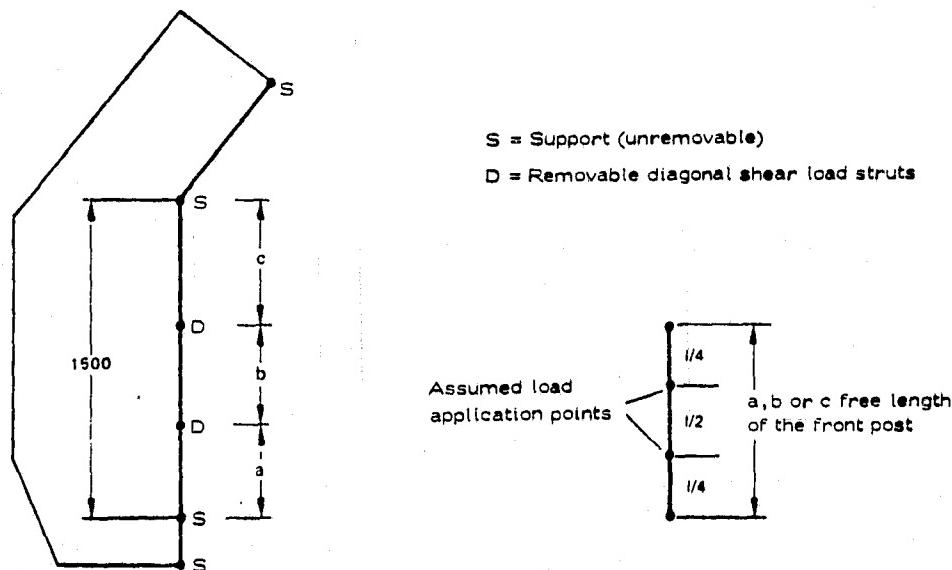


Figure 3.2 - 35a : Two Diagonal Shear Load Struts Installed

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Figure 3.2 - 35a shows three subsections in the lower part of the rack (marked as a, b and c) which are defined by the locations of two removable shear load struts. The assumed load application points are the application points of the inertial forces of the equipment mass in a specific subsection.

Table 3.2 - 2 indicates the overall load carrying capabilities for various mass distributions and several positions of the diagonal shear load struts. For alternative mass distributions and shear load strut locations, additional analyses will be needed.

The equipment mass in each subsection is basically limited by the capabilities of the front mounted attachment. Substantial increase of the allowable masses in the subsections is feasible by virtue of front mounted/back supported or shelf mounted installation.

Figure 3.2 - 36a shows the increased loading capability ratio as a function of the c.g. location d for front mounted/back supported equipment in relation to front mounted equipment. The parameter L denotes the location of the back support pin.

Figure 3.2 - 36b shows the respective load gain function for shelf-mounted equipment, also as a function of c.g. location.

It is important to observe that under any circumstances the overall mass accommodated in the lower part of a double rack must not exceed 435 kg and that neither side of the lower part exceeds 207 kg.

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Table 3.2 - 2 : Overall Load Carrying Capability of a Single Rack or Each Side of a Double Rack for
 - Rack Lower Part
 - Two (2) Diagonal Shear Load Struts Installed
 - Equipment Masses in Subsections (Front Mounted)

SHEAR LOAD STRUT LOCATION			MASS RATIOS			TOTAL ALLOWABLE MASS	MASS ALLOWABLE IN SUBSECTIONS M_{eq}		
a	b	c	a	b	c	(kg)	a (kg)	b (kg)	c (kg)
500	500	500	1	1	1	266,78	88,93	88,93	88,93
			0,5	1	1,5	266,80	44,47	88,93	113,40
			1,5	1	0,5	218,69	109,34	72,90	36,45
			0	1	2	266,78	0	88,93	177,86
			2	1	0	178,65	119,10	59,55	0
			2	0	1	226,69	150,73	0	75,38
			1	0	2	266,78	88,93	0	177,86
300	600	600	1	1	1	266,78	88,93	88,93	88,93
			0,5	1	1,5	266,80	44,47	88,93	133,40
			1,5	1	0,5	233,73	116,86	77,91	38,96
			0	1	2	266,78	0	88,93	177,86
			2	1	0	198,93	132,62	66,31	0
			2	0	1	266,78	177,86	0	88,93
			1	0	2	266,78	88,93	0	177,86
600	600	300	1	1	1	255,93	85,31	85,31	85,31
			0,5	1	1,5	266,80	44,47	88,93	133,40
			1,5	1	0,5	186,70	93,35	62,23	31,12
			0	1	2	266,79	0	88,93	177,86
			2	1	0	146,95	97,97	48,98	0
			2	0	1	176,76	117,84	0	58,92
			1	0	2	266,79	88,93	0	177,86
600	300	600	1	1	1	266,79	88,93	88,93	88,93
			0,5	1	1,5	266,80	44,47	88,93	133,40
			1,5	1	0,5	207,25	103,63	69,08	34,54
			0	1	2	266,79	0	88,93	177,86
			2	1	0	165,01	110,01	55,00	0
			2	0	1	200,42	133,62	0	66,80
			1	0	2	266,79	88,93	0	177,86
450	600	450	1	1	1	266,79	88,93	88,93	88,93
			0,5	1	1,5	266,80	44,47	88,93	133,40
			1,5	1	0,5	211,95	105,97	70,65	35,33
			0	1	2	266,79	0	88,93	177,86
			2	1	0	173,20	115,47	57,73	0
			2	0	1	227,40	151,60	0	75,80
			1	0	2	266,79	88,93	0	177,86

Case 2 : One removable diagonal shear load strut in the lower part of the rack.

The location of the diagonal shear load strut is shown in Figure 3.2 -35b. The overall load carrying capability is given in Table 3.2 - 3. For load increase possibilities in the subsections, see the foregoing description of Case 1.

S = Supports (unremovable)

D = Diagonal shear load strut

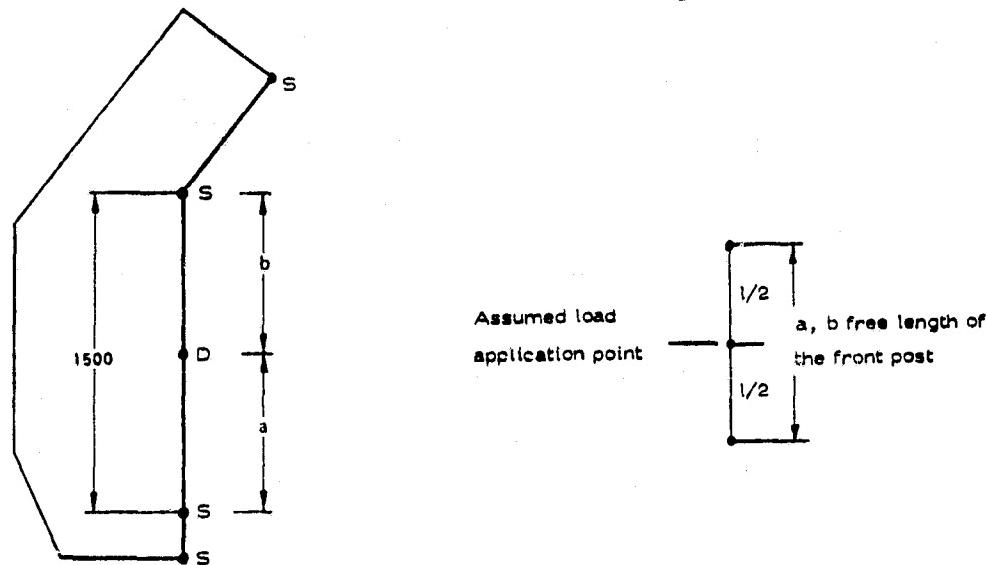


Figure 3.2 - 35b: Location of Diagonal Shear Load Strut

Table 3.2 - 3: Overall Load Carrying Capability for a Single Rack or Each Side of a Double Rack

- Rack Lower Part
- One (1) Diagonal Shear Load Strut Installed
- Equipment Masses in Subsections (Front Mounted)

SHEAR LOAD STRUT LOCATION		MASS RATIOS		TOTAL ALLOWABLE MASS	MASS ALLOWABLE IN SUBSECTIONS M_{eq}	
a	b	a	b	(kg)	a (kg)	b (kg)
750	750	1	1	191	95.50	95.50
		0.5	1.5	165.68	41.42	124.26
		1.5	0.5	145.91	109.43	36.48
		1	2	124.68	0	124.68
		2	0	118.06	118.06	0
600	900	1	1	187.06	93.53	93.53
		0.5	1.5	212.75	53.19	159.56
		1.5	0.5	150.59	112.94	37.65
		0	2	162.12	0	162.12
		2	0	125.96	125.96	0
900	600	1	1	210.70	105.35	105.35
		0.5	1.5	261.95	65.49	196.46
		1.5	0.5	156.48	117.36	39.12
		0	2	197.75	0	197.75
		2	0	124.38	124.38	0

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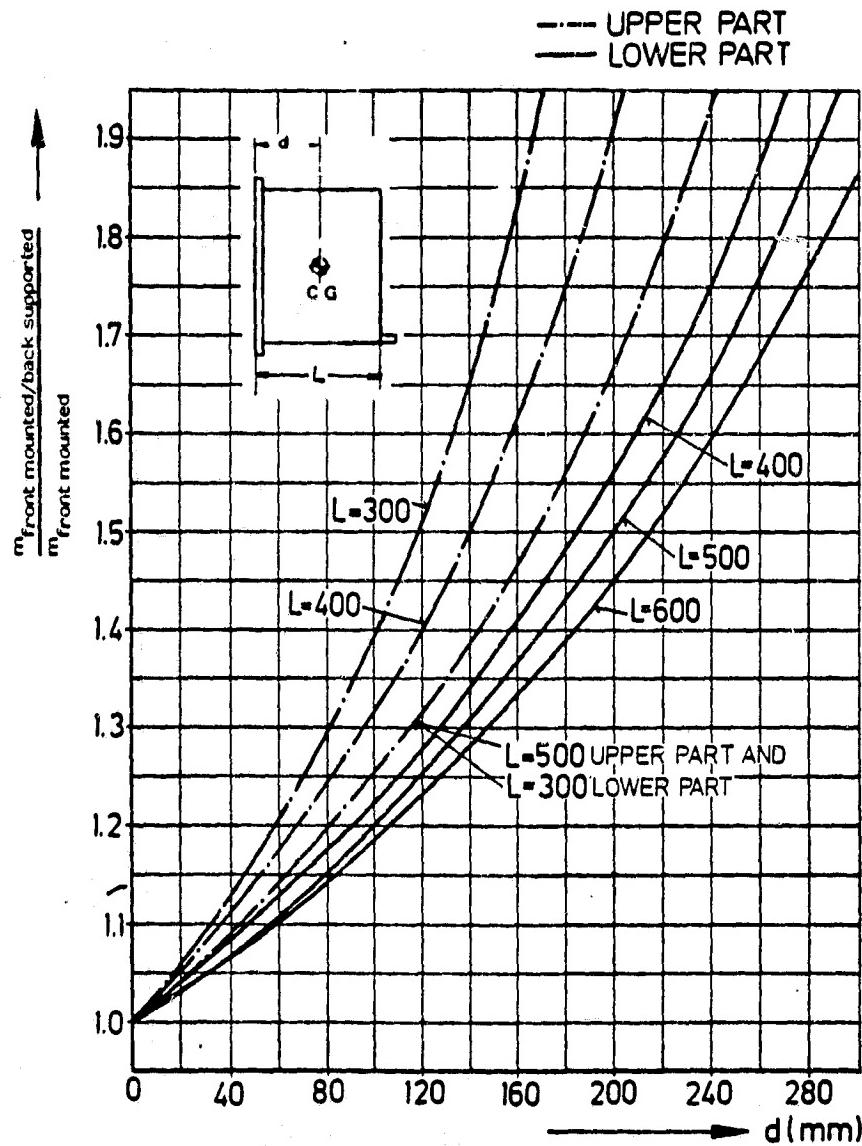
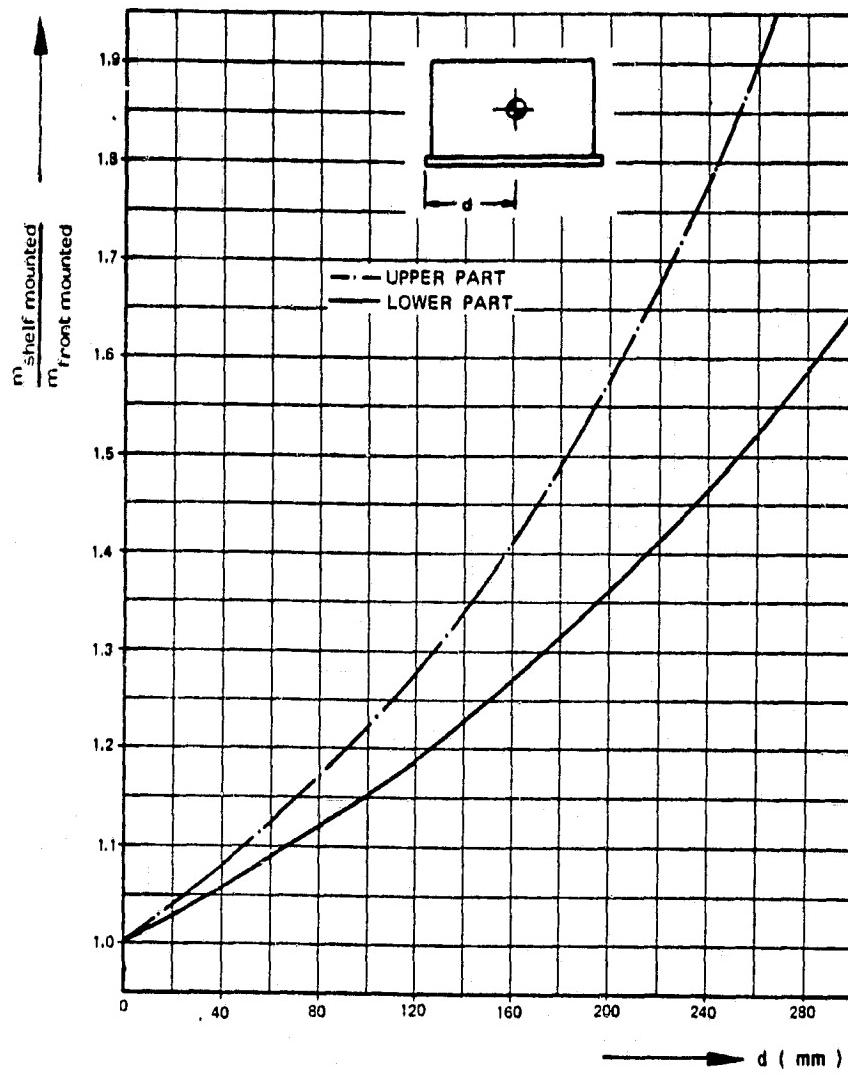


Figure 3.2 - 36a: Load Gain Factor for Front Mounted/Back Supported Equipment



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Figure 3.2 - 36b: Load Gain Factor for Shelf Mounted Equipment

Case 3 : No removable shear load strut in the lower part of the rack

For this case, a reduced capability of $m = 50$ kg is estimated under the assumption that the mass will be installed as close as possible to the lower supports. Substantial increase of loading capability is possible by non-standard methods such as

- structural integration of shelf platforms for equipment mounting which act as horizontal shear panels
- rigid installation of front shear panels, contrary to the assumption that standard front panels shall not transfer shear loads

Either solution will require a case-by-case analysis .

Case 4 : Center wall removed in the lower part of a double rack

- Same as for Case 3 -

3.2.6.2 Local Load Carrying Capability of Single and Double Rack

The standard experiment racks provide for a certain envelope (para 3.2.1) and a set of standard attachment interfaces (para 3.2.2) for the installation of experiments.

3.2.6.2.1 Local Load Carrying Capability

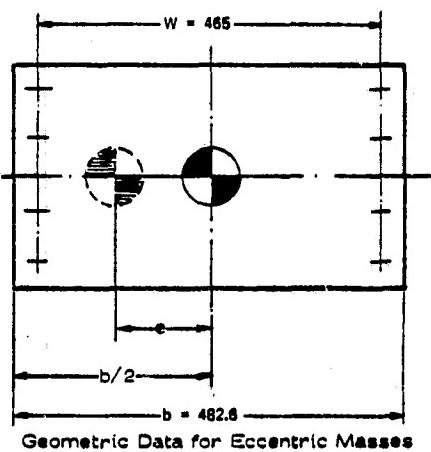
The local load carrying capabilities provided are calculated under the following assumptions which represents the minimum fixations:

1. The experiment front panel (hole location and geometry) is in accordance with MIL-STD-189 closed slot type (for details see para 3.2.2)
2. Three mounting types ,which have been standarized, are considered
 - (a) cantilevered front mounted equipment (para 3.2.6.2.2)
 - (b) front mounted, back supported equipment (para 3.2.6.2.3)
 - (c) shelf mounted equipment (para 3.2.6.2.4)
3. No shear loads shall be transferred from the rack structure to the equipment front panel or equipment box. Therefore each equipment of the (a) and (b) - type transfers the "X-Load" at the rack frontal plane, only by means of one attachment point. The location of this attachment point shall be as near as possible to the diagonal struts or the rack stiffened areas (top and bottom of front side posts and the front side posts at rack knee) and always on the front side posts. Transfer of "X-loads" at the rear end area of the rack will be performed by a pair of positioning pins for (b)-type equipment. The "Z-Load" is transferred at the rack frontal plane by means of only two attachment points of the (a) and (b) type equipment. For (b)-type equipment, transfer of "Z-loads" at the rear end area of the rack will likewise be performed by the positioning pins. For all rack mounted equipment, the "Y-load" will be transferred by means of all front bolts in a linear distribution over the front panel height. For details see Figure 3.2 - 39 "Front Mounted Equipment" and Figure 3.2 - 41 "Front Mounted, Back Supported Equipment".
4. Each (c)-type panel transfers the load in all directions by means of one attach hole at each of the two front and rear posts.
5. Each equipment center of gravity (c.g.) is assumed in the middle of the box with a variance in depth (i.e. Y-direction).

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6. c.g. eccentricities in x-axis must be accounted for by reducing the allowable mass in accordance with the following equation based on the geometry given.

$$m_{ecc} = m(1 - |e|/b)$$



7. With reference to the mechanical environment described in para 3.2.7 each equipment is assumed to have a hard mounted resonance frequency of > 35 to 60 Hz for the determination of the load factor.

8. If the equipments have hard mounted frequencies of $f_0 > 60$ Hz, the masses of the equipments have to be reduced accordingly by the ratio of load factors (see para 3.2.7).

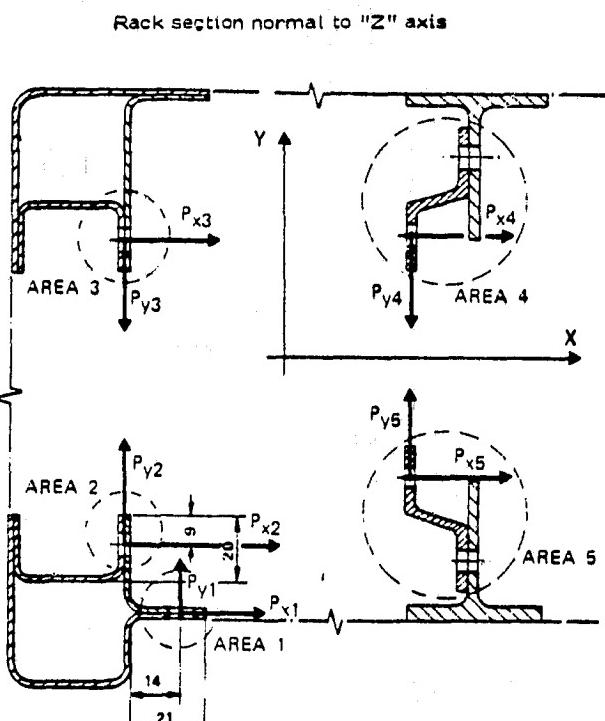
$$m_f = (n_{f1}/n_{f2}) m$$

with n_{f1} : load factor for $35 < f_0 < 60$ Hz

n_{f2} : load factor for $f_0 > 60$ Hz

9. Critical local areas

The critical areas of the rack which limit the local carrying capability are shown in the following figure:



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Figure 3.2 - 37a: Critical Areas for Local Carrying Capability

Note: - The directions of the forces are not coincident with the direction of the coordinate system
- The local capabilities of front mounted/back supported equipment and shelf-mounted equipment are also limited by the critical areas 4 and 5 in the present analysis, which is very conservative. A respective stress analysis of alternative equilibrium systems may result in more favorable data.

The maximum allowable limit loads (see Fig. 3.2 - 37b) can be derived from the following equation for

- area 1

$$0.024 P_{x1} + 0.556 P_{y1} < 385.5 \text{ N}$$
$$P_{x1} < 5493.6 \text{ N}$$

- area 2 and area 3

$$0.5 P_{y2,3} + 0.019 P_{x2,3} < 385.5 \text{ N}$$
$$P_{y2,3} < 5493.6 \text{ N}$$

- area 4 and area 5

$$0.245 (P_{x4,5} + P_{y4,5}) < 385.5 \text{ N}$$

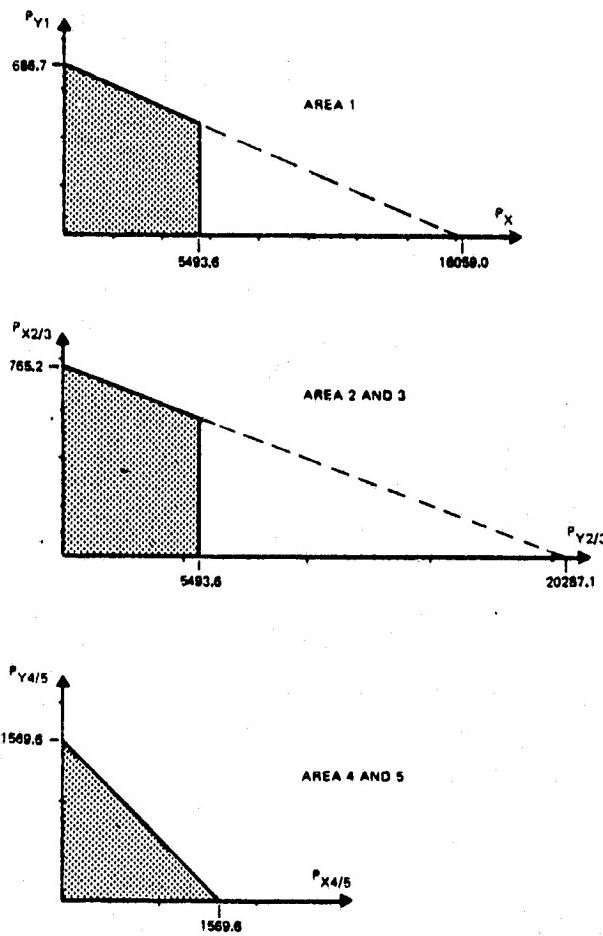


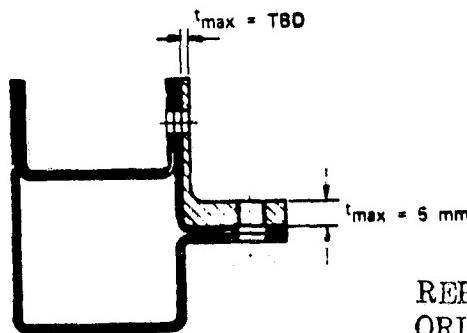
Figure 3.2 - 37b : Allowable Limit Loads

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Local improvements of the critical areas 1, 2 and 3 can be reached by reinforcing the critical location (see Fig. 3.2 - 37c).



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Figure 3.2 - 37c: Front Side Post Reinforcement

The changed allowables are then TBD.

3.2.6.2.2 C.G./Mass Limitation for Front Mounted Equipment

The system of equilibrium of the front mounted equipment is given in Figure 3.2 - 39.

The limitation of this payload configurations is mainly given by the y-reaction loads and less by the x-reaction load at the front side post (see Fig. 3.2 - 38).

The "full" fixation point (F_x , F_y , F_z) can be placed either one of the four edge holes. This "full" fixation point shall be as near as possible to the diagonal shear load strut or rack stiffened areas (Point D and S of Fig. 3.2 - 35a and 3.2 - 35b) and shall be attachment point at the front side post and never of the front center post (see Fig. 3.2 - 38).

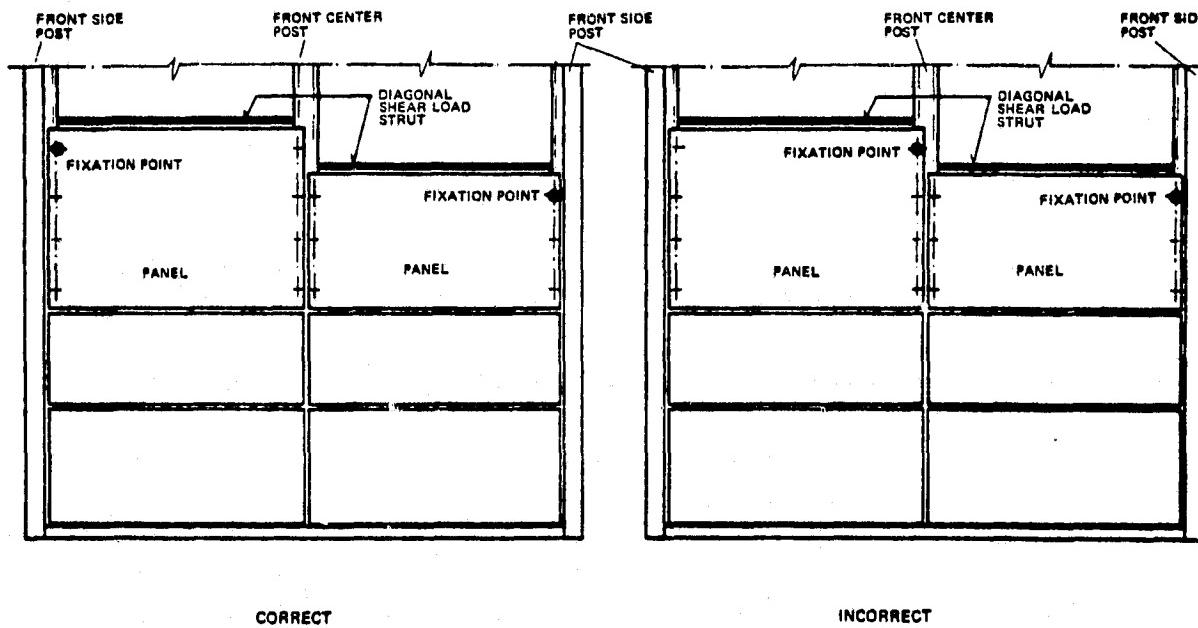
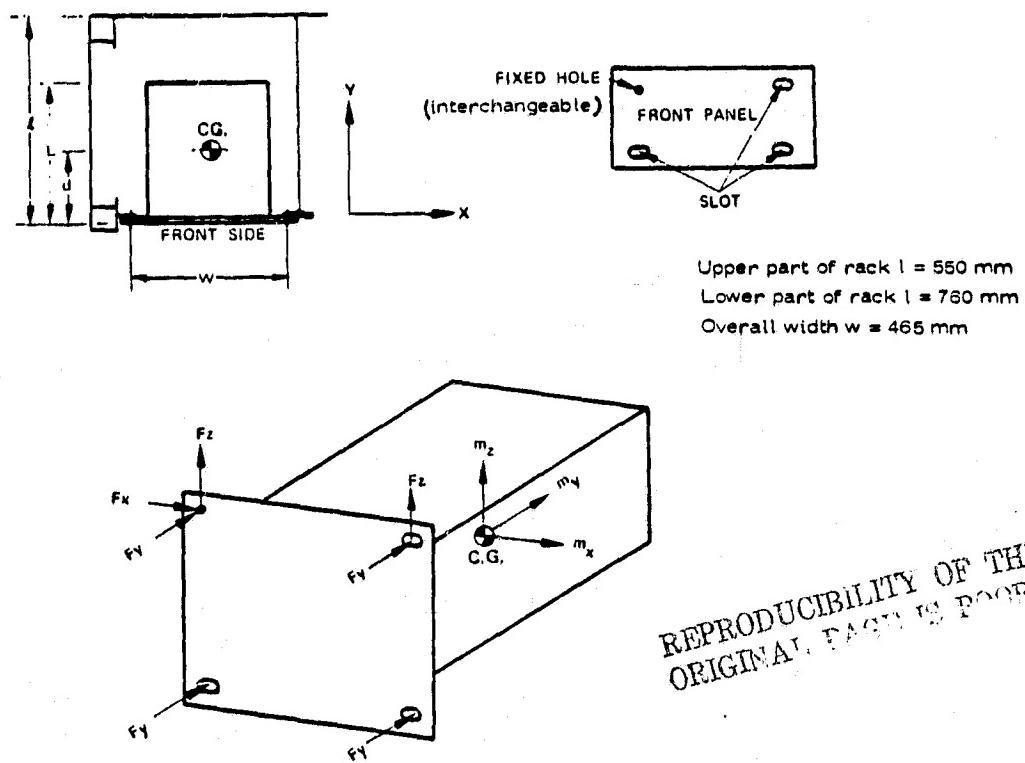


Figure 3.2 - 38: Fixation Points

Figure 3.2 - 40a thru 3.2 - 40c give the C.G./mass limitation for front mounted equipment.

Figure 3.2 - 39: Front Mounted Equipment (4 Holes)
(System of Equilibrium)

Note : "Full" fixation point (F_x , F_y , F_z) near diagonal shear load strut or rack stiffened areas and at the front side post, never at the front center posts.

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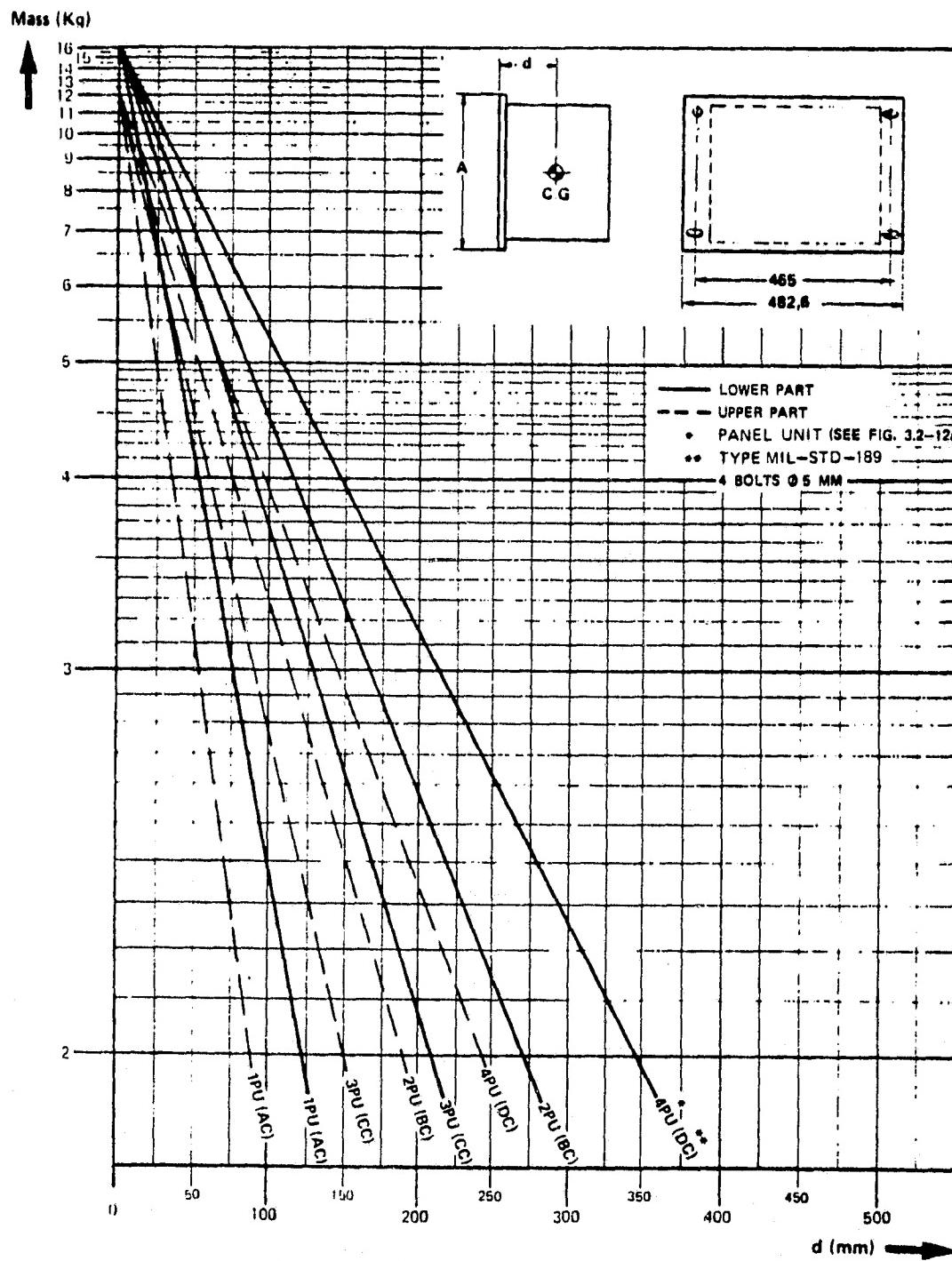


Figure 3.2 - 40a : Rack Load Carrying Capability (Front Mounted)

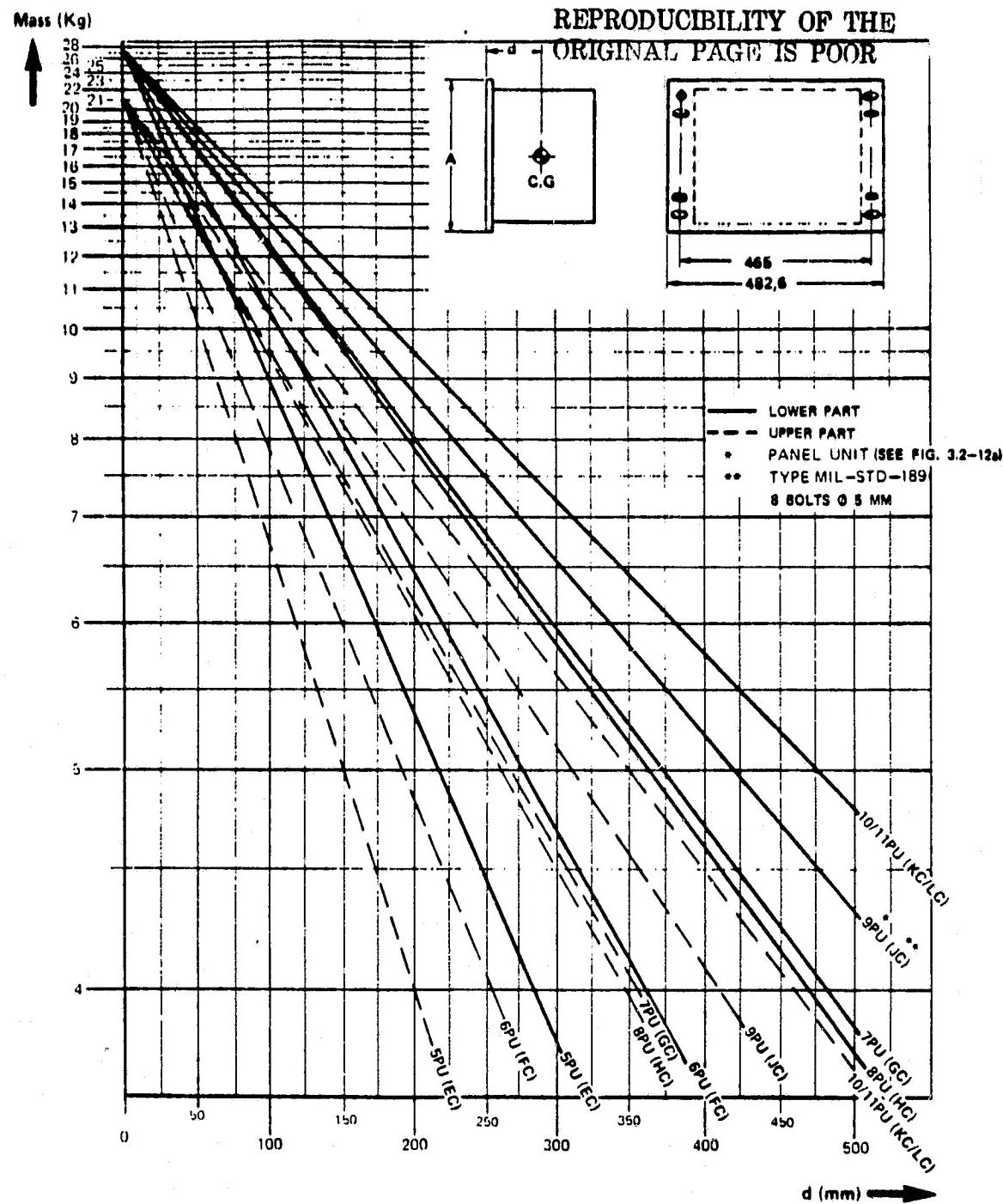


Figure 3.2 - 40b: Rack Load Carrying Capability (Front Mounted)

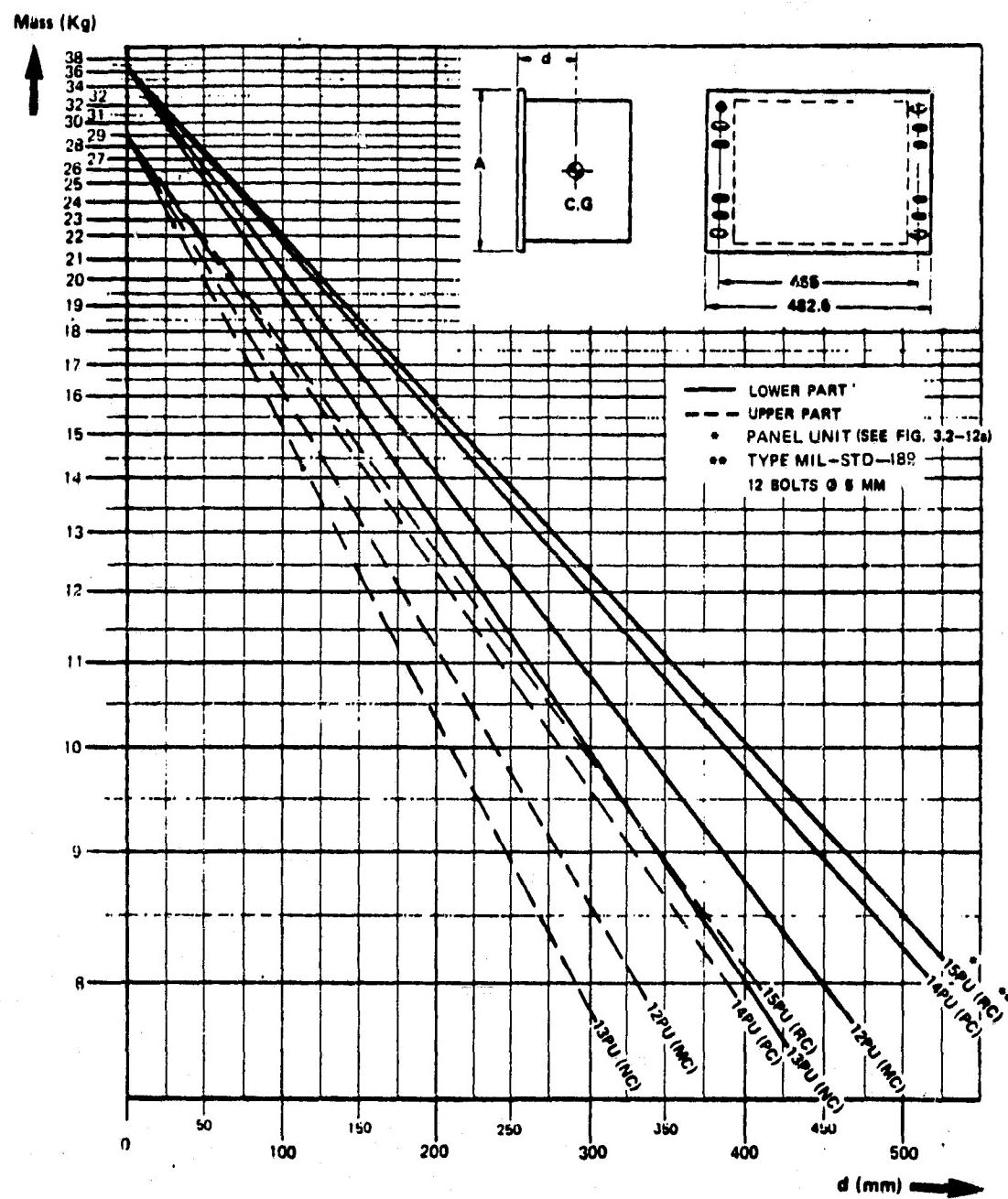


Figure 3.2 - 40c: Rack Load Carrying Capability (Front Mounted)

3.2.6.2.3 C.G. / Mass Equilibrium for Front Mounted / Back Supported Equipment

The system of equilibrium for front mounted/back supported equipment is given in Figure 3.2 - 41. The load limiting critical areas of this system are Position 1 and 2 at the front post, and Position 4 at the rear post. However, the present analysis is very conservative because the x-loads are assumed to act on the rear center post, which is only a Z-profile, instead on the rear side post, which is much stiffer.

Explanation of the fixed hole see Fig. 3.2 - 38.

The system of equilibrium shows that the installed equipment is elastically clamped at the front post and simply supported at the rear via guide pins by the rear post, which is considered to be a simply supported beam.

Denotations:	E_{B1B}	bending stiffness of the equipment box; the box can be assumed to be infinitely rigid
	E_{S1S}	bending stiffness of the support structure beam AB which is attached to the side posts
	K_ϕ	stiffness of the elastic hinge

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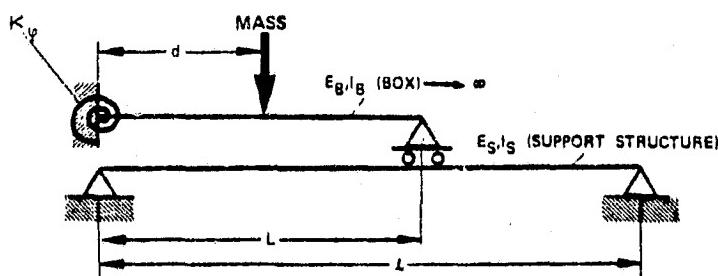
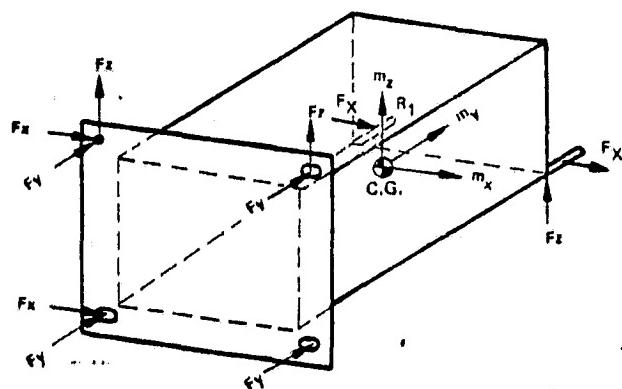
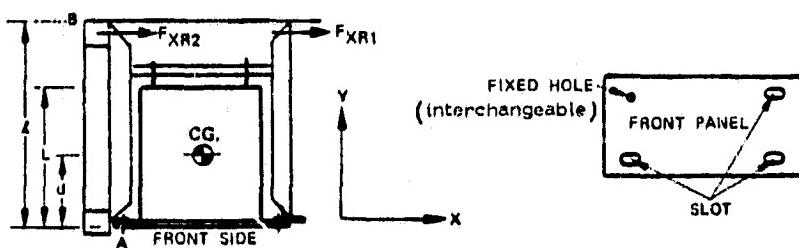


Figure 3.2 - 41 a: Front Mounted, Back Supported Equipment (4 Holes)
(System of Equilibrium)

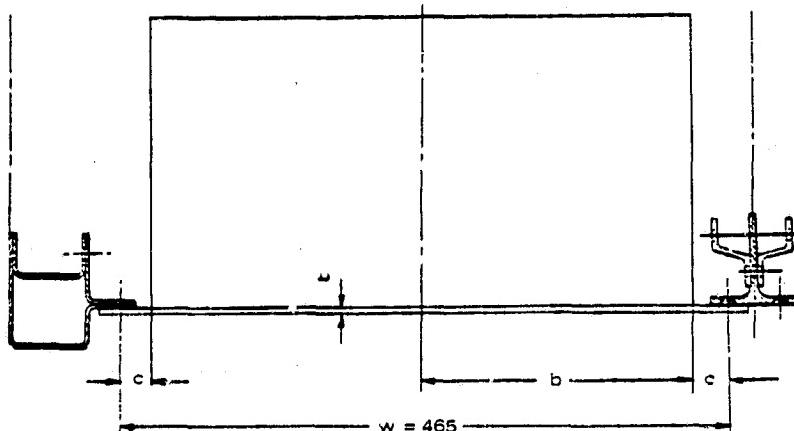


Figure 3.2 - 41 b: Parameters for the Determination of the Elastic Properties

The panel is assumed to be hinged in the bolt line and clamped at the box resulting the following formula for K_p

$$K_p = \frac{E b^2 t^3 A}{2 c^3}$$

with $b = (w-2c)/2$

t = panel thickness

A = panel height (see Fig. 3.2 - 12a)

E = Young Modulus of the panel

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Figures 3.2 - 42a thru 3.2 - 42h give the C.G./mass limitation for the front mounted back supported equipment. The figures are given for a parameter

$$S = \frac{E_S I_S}{K_p} = 140$$

The curves are explained in Figure 3.2 - 41c. For other stiffness ratios ($S \neq 140$), see the nomograms in Figures 3.2 - 45a thru 3.2 - 45h.

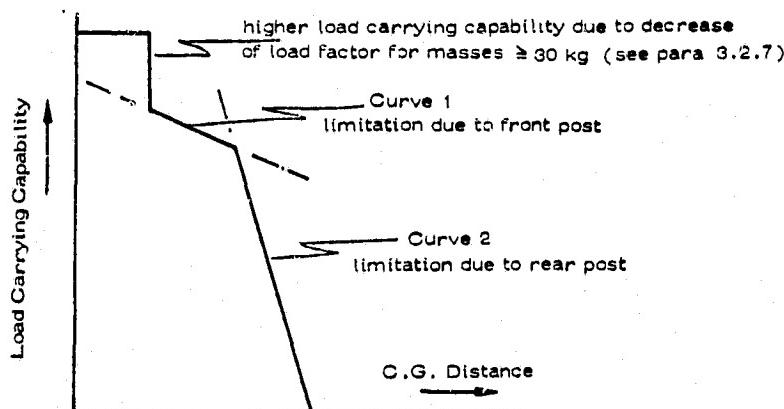


Figure 3.2 - 41c: Interpretation of Rack Load Curves

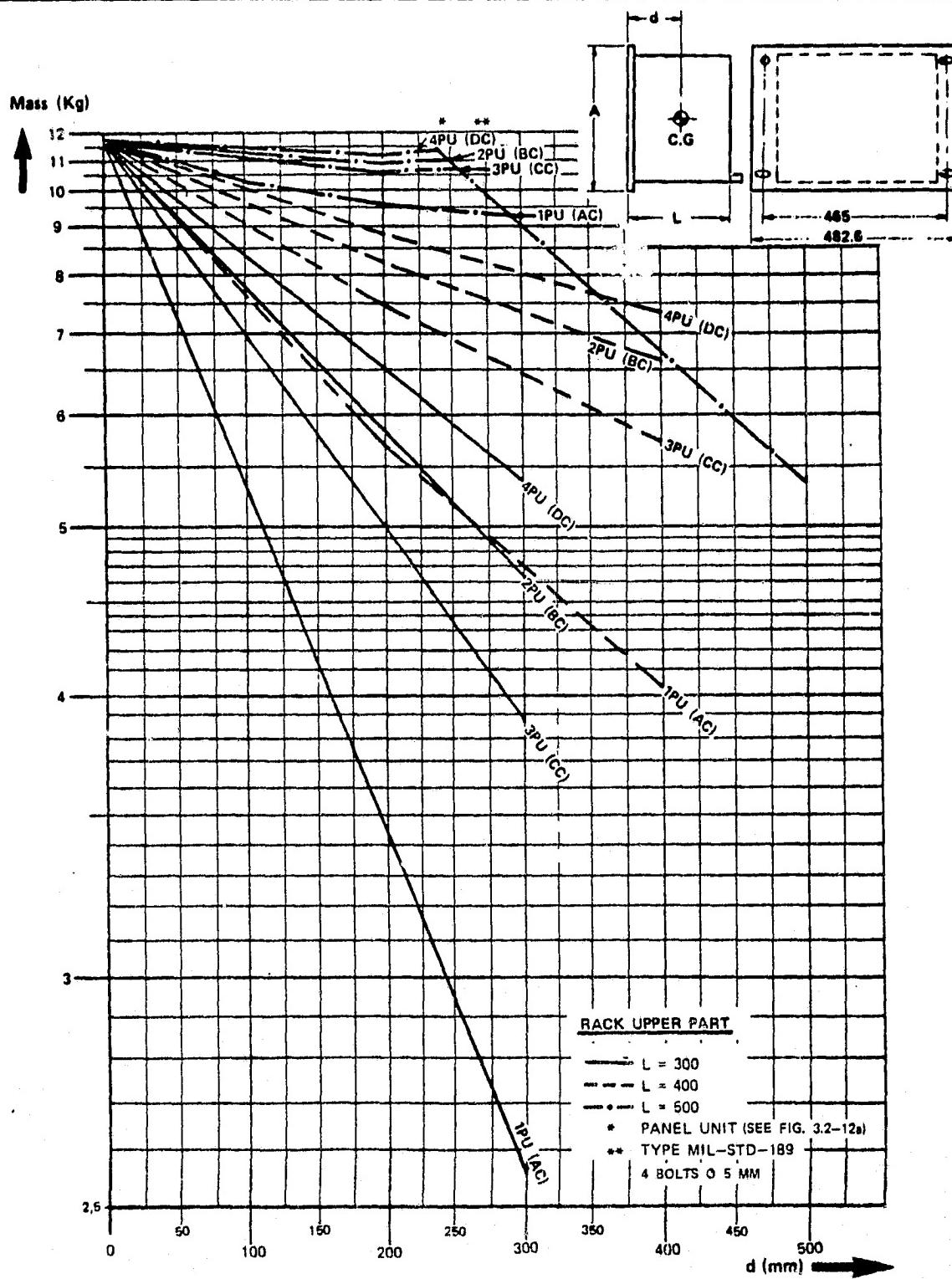


Figure 3.2 - 42a: Rack Load Carrying Capability (Front mounted, Back Supported)

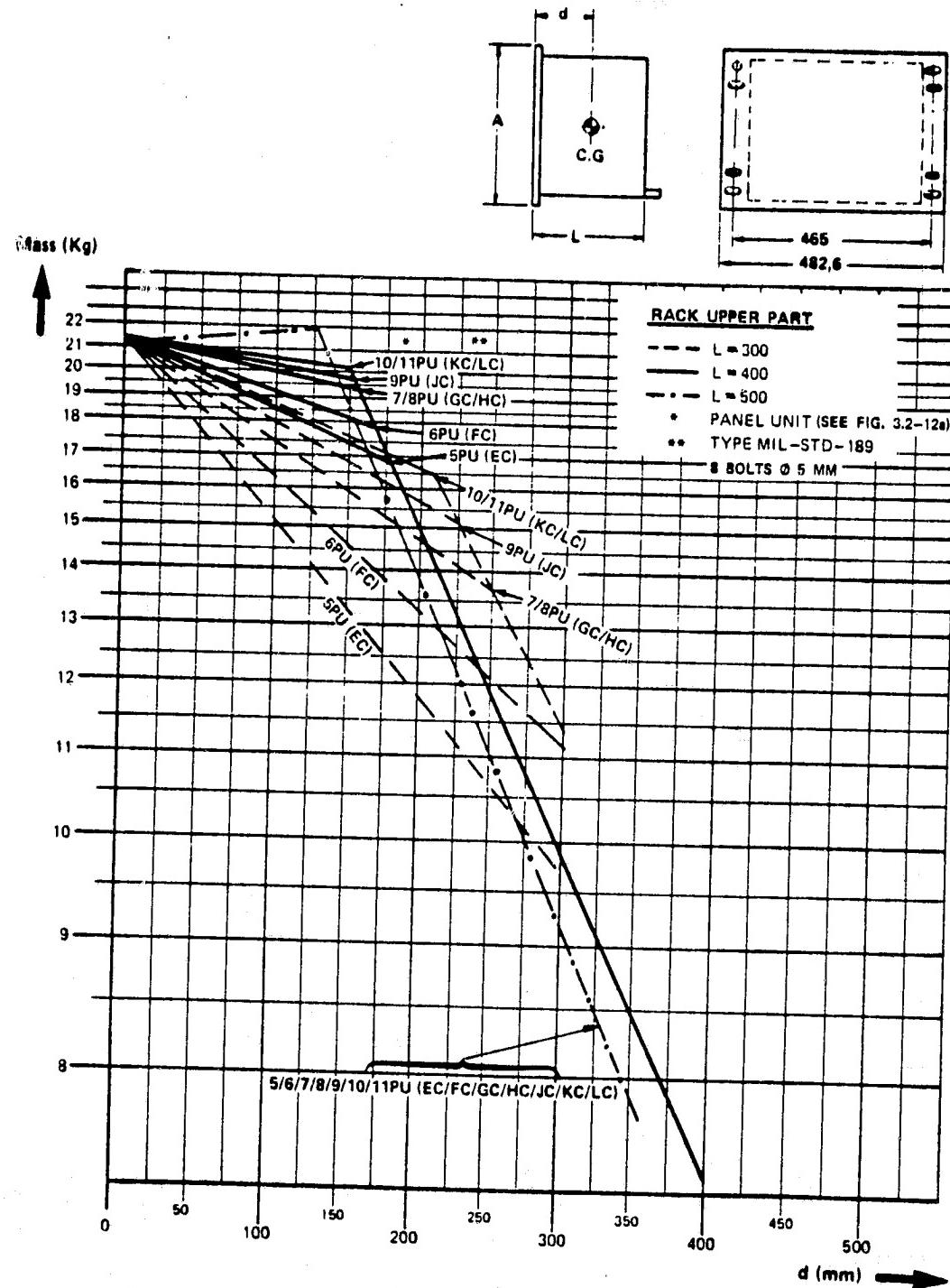


Figure 3.2 - 42b: Rack Load Carrying Capability (Front Mounted, Back Supported)

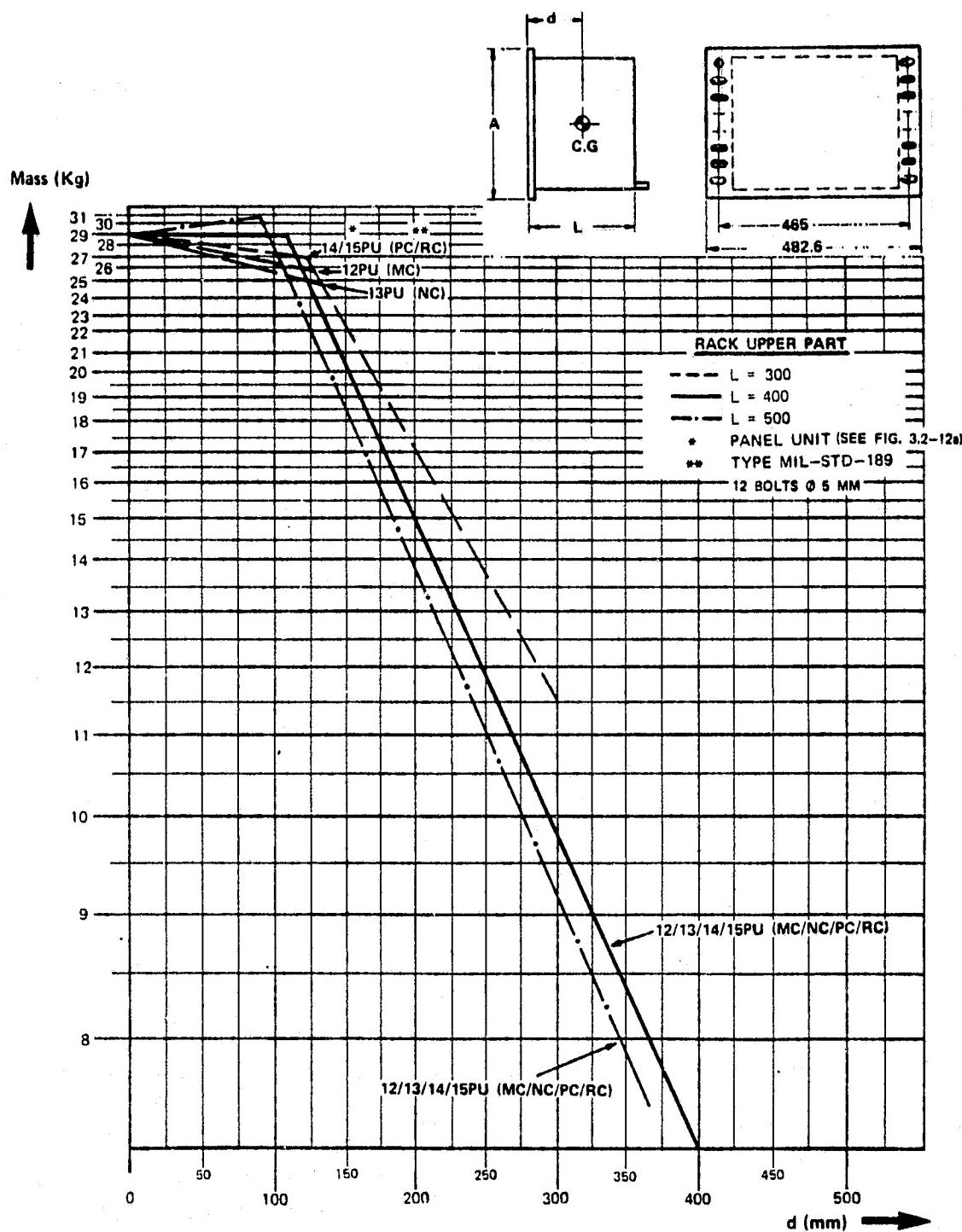


Figure 3.2 - 42c: Rack Load Carrying Capability (Front Mounted, Back Supported)

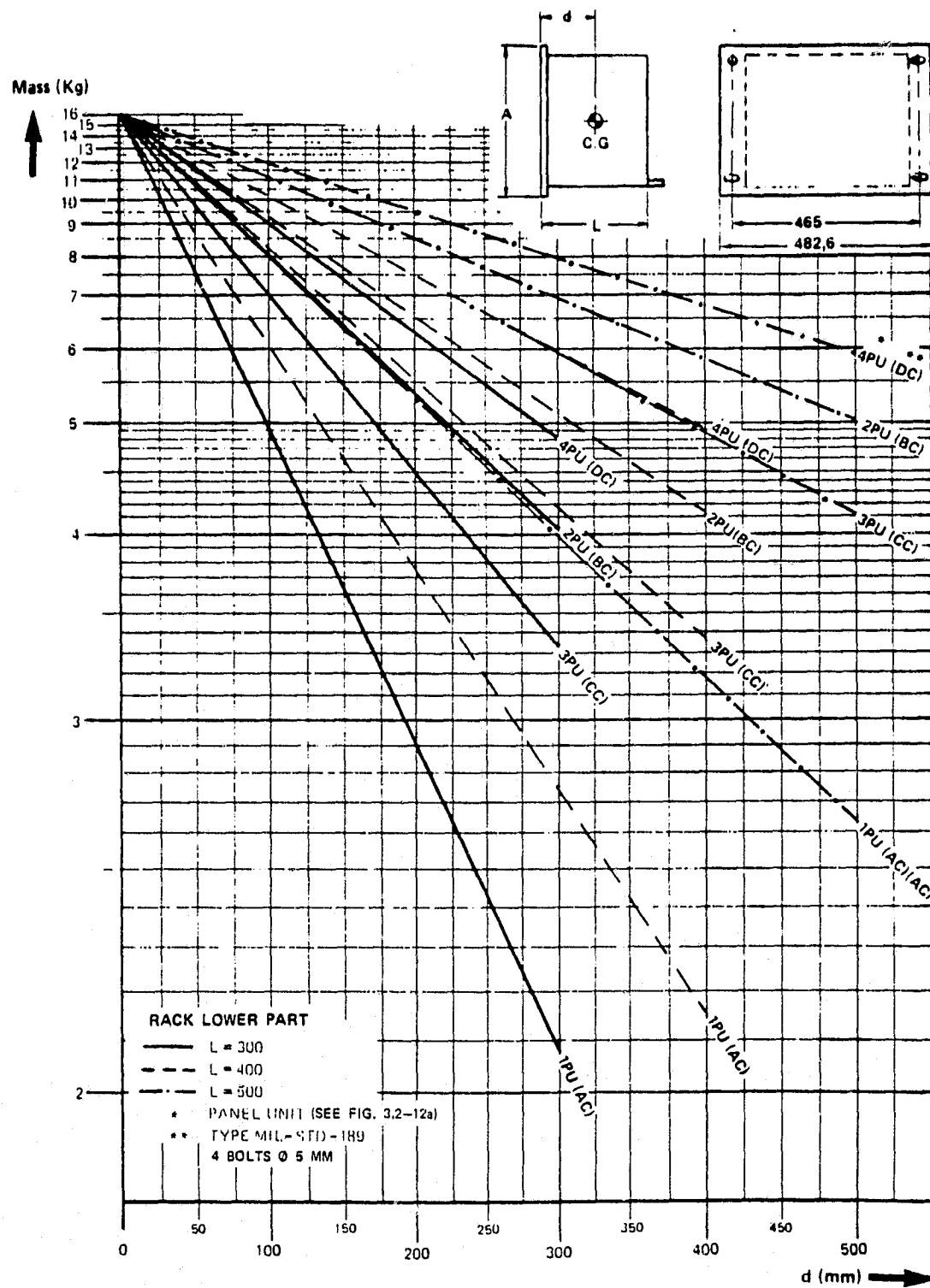


Figure 3.2 - 42d: Rack Load Carrying Capability (Front Mounted, Back Supported)

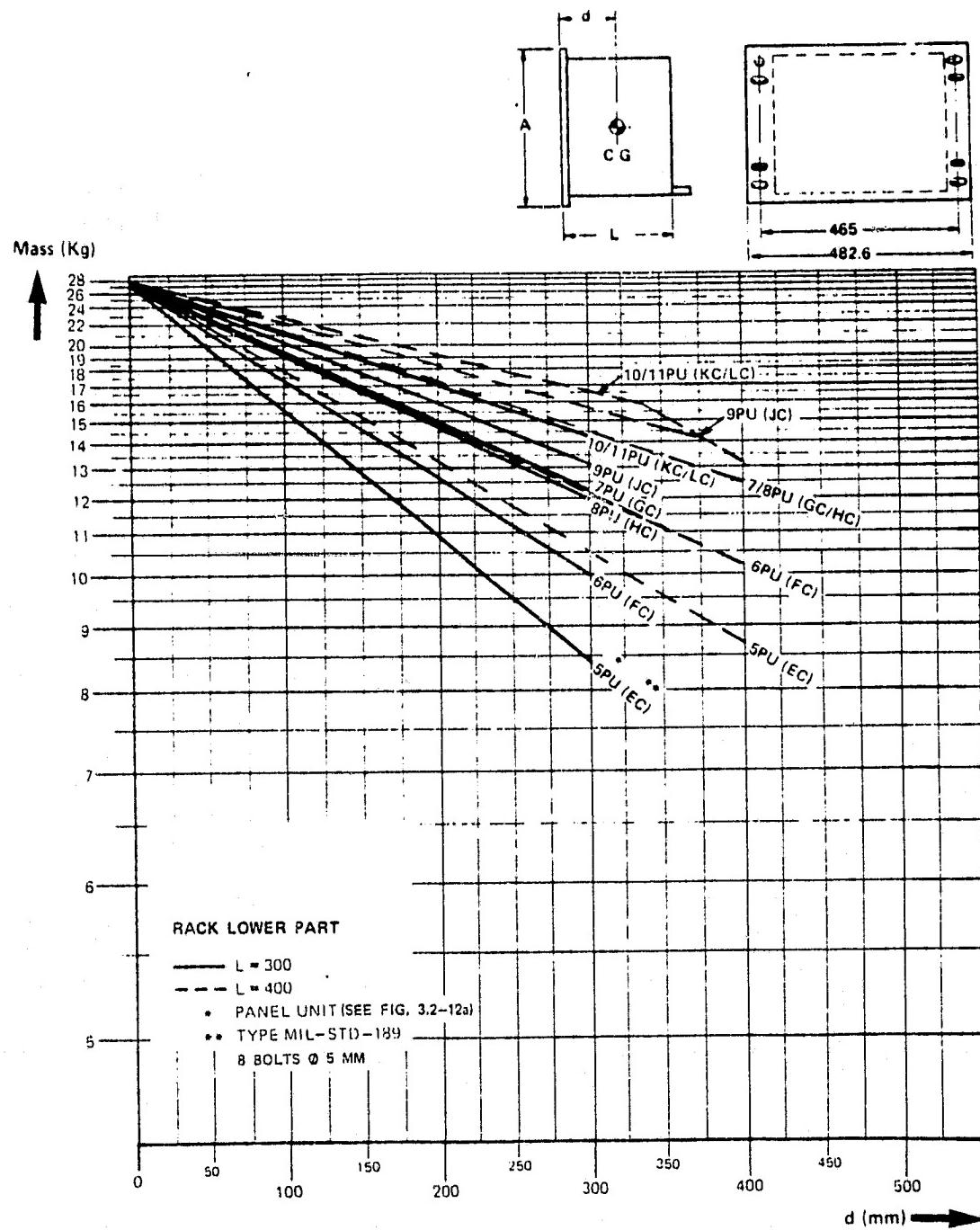


Figure 3.2 - 42e: Rack Load Carrying Capability (Front Mounted, Back Supported)

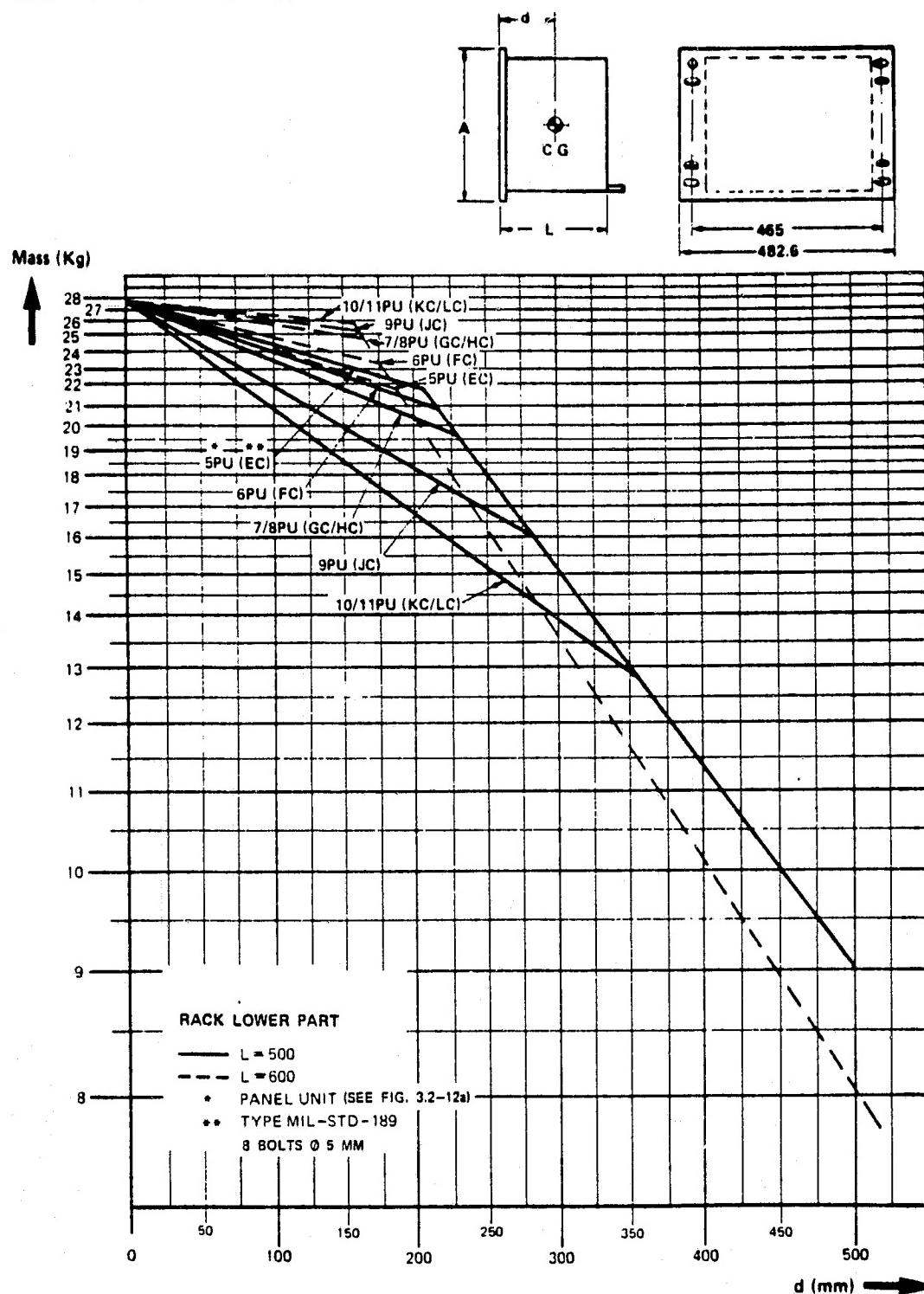


Figure 3.2 - 42f: Rack Load Carrying Capability (Front Mounted, Back Supported)

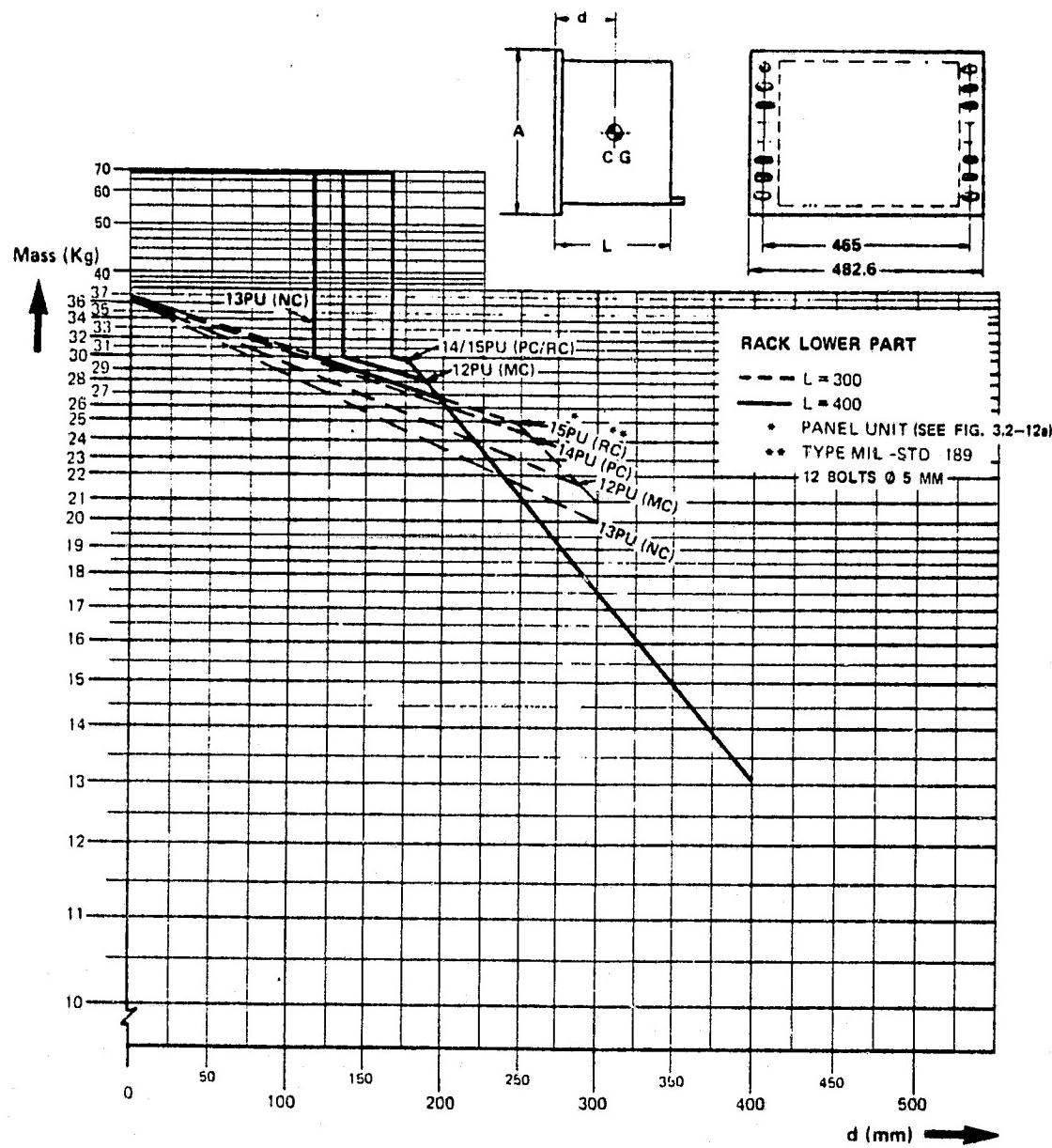


Figure 3.2 - 42g: Rack Load Carrying Capability (Front Mounted, Back Supported)

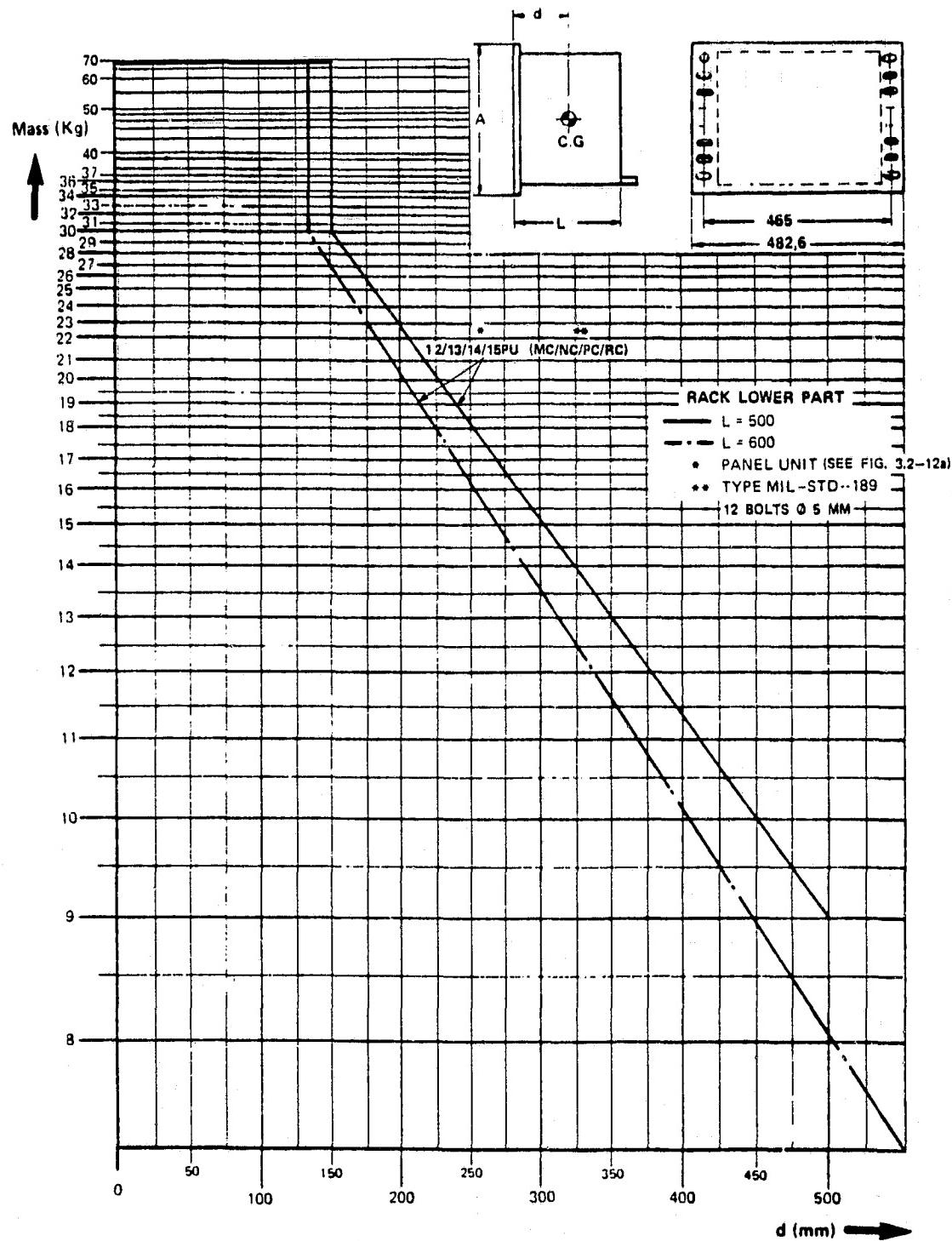


Figure 3.2 - 42h: Rack Load Carrying Capability (Front Mounted, Back Supported)

While the foregoing curves, describing the rack load carrying capabilities for front mounted/back supported equipment, are only valid for a stiffness ratio $S = 140$, subsequent nomograms serve to calculate the load carrying capabilities for deviating stiffness ratios.

For Curve 1 the respective factors can be found in Figures 3.2 - 45a thru 3.2 - 45g, as explained in Figure 3.2 - 43.

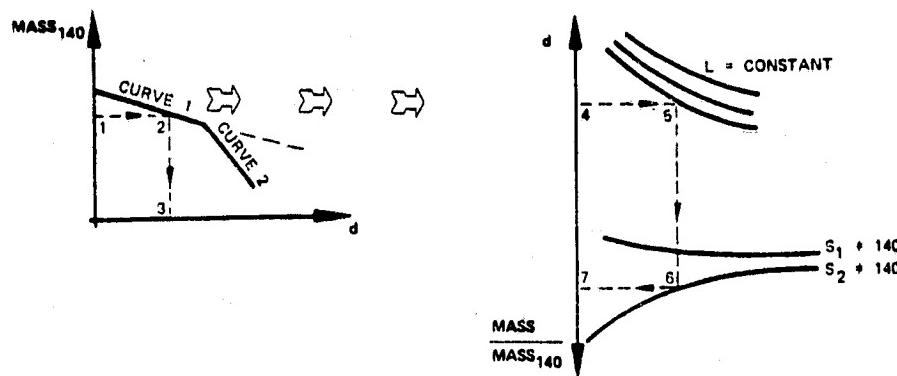


Figure 3.2 - 43: Nomographic Correction of Curve 1 for $S \neq 140$

For Curve 2 the factors given in Figure 3.2 - 45h are applicable, as explained in Figure 3.2 - 44.

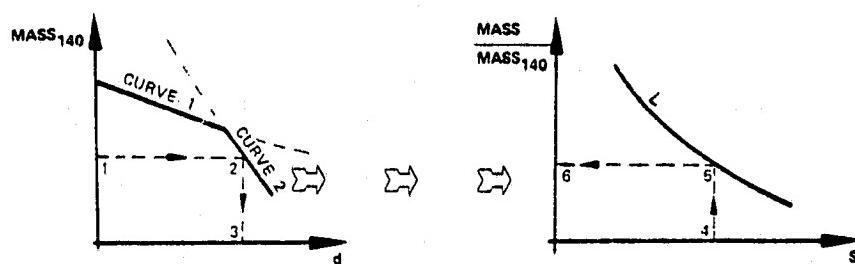


Figure 3.2 - 44: Nomographic Correction of Curve 2 for $S \neq 140$

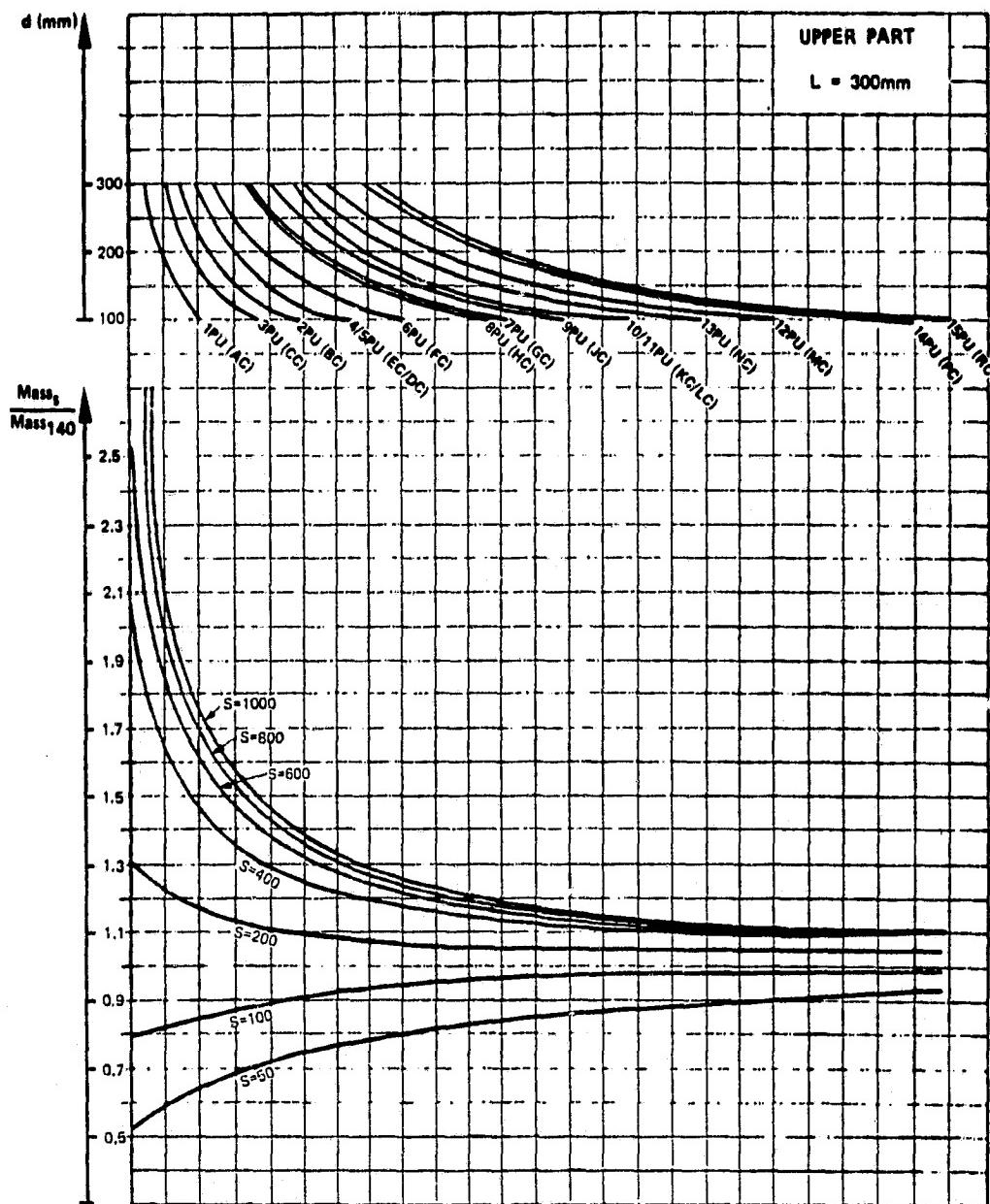


Figure 3.2 - 45a: Rack Load Carrying Capability
(Front Mounted and Back Supported; $S \neq 140$)

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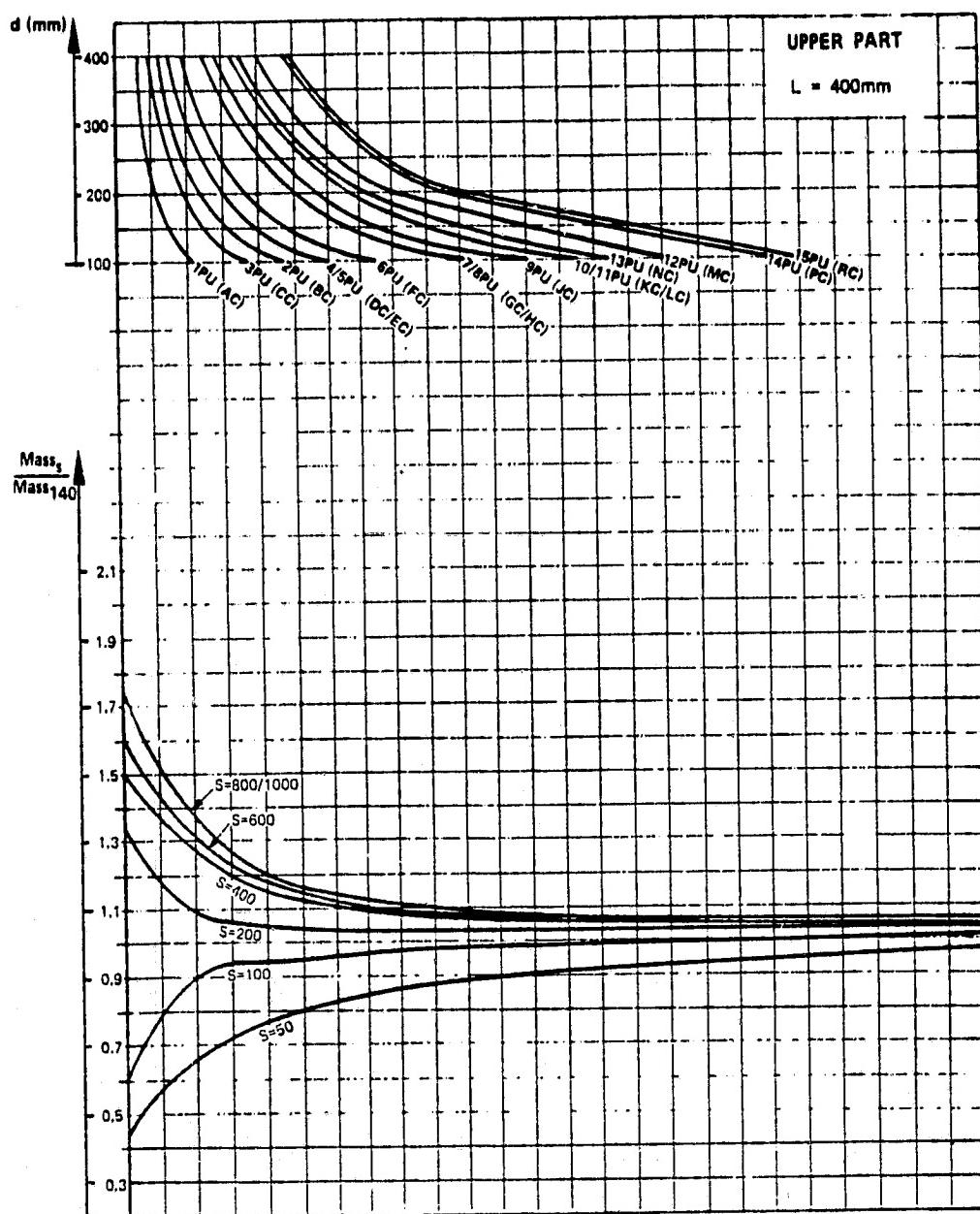


Figure 3.2 - 45b: Rack Load Carrying Capability (Front
Mounted and Back Supported; $S = 140$)

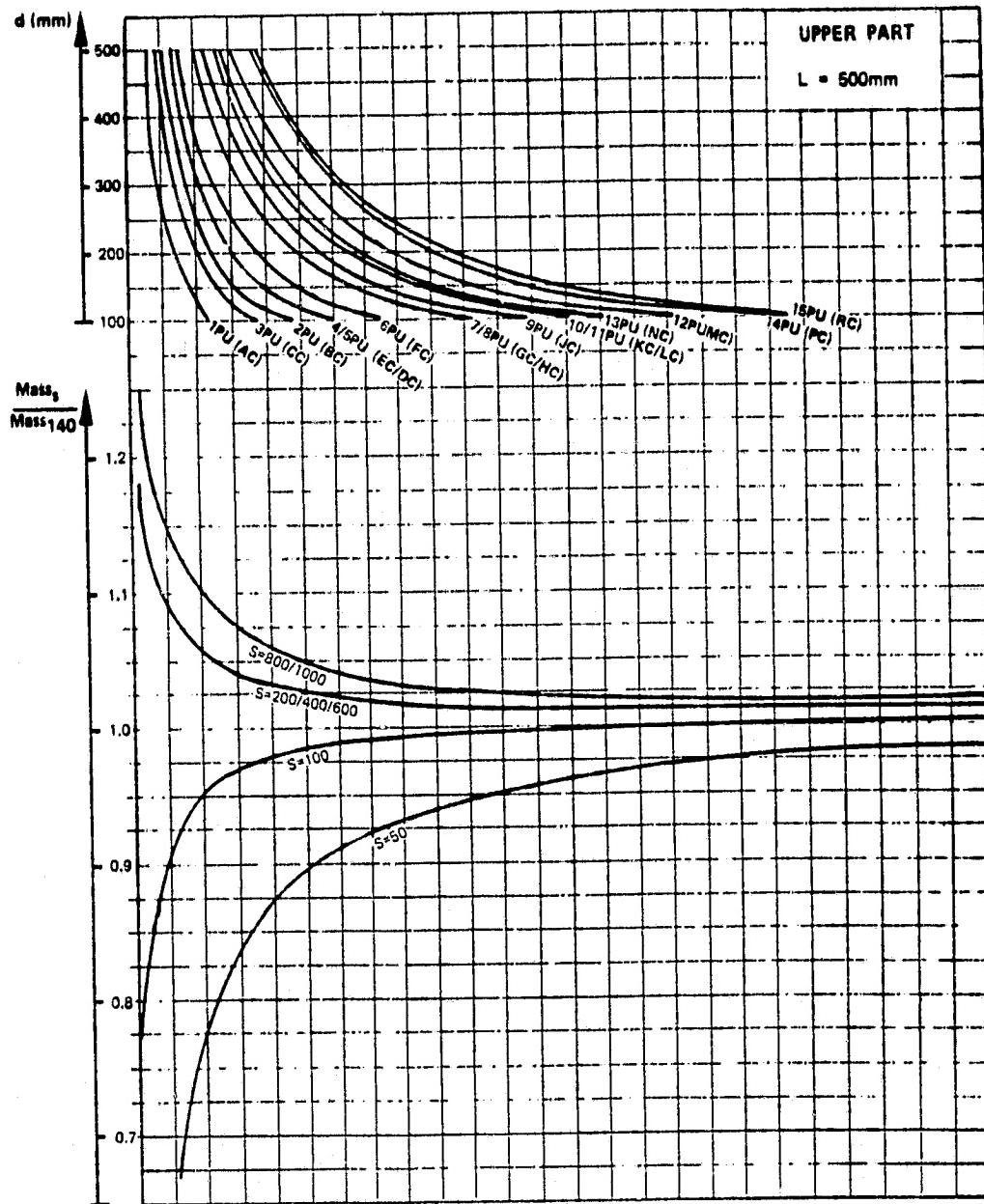


Figure 3.2 - 46c: Rack Load Carrying Capability (Front
Mounted and Back Supported; $S = 140$)

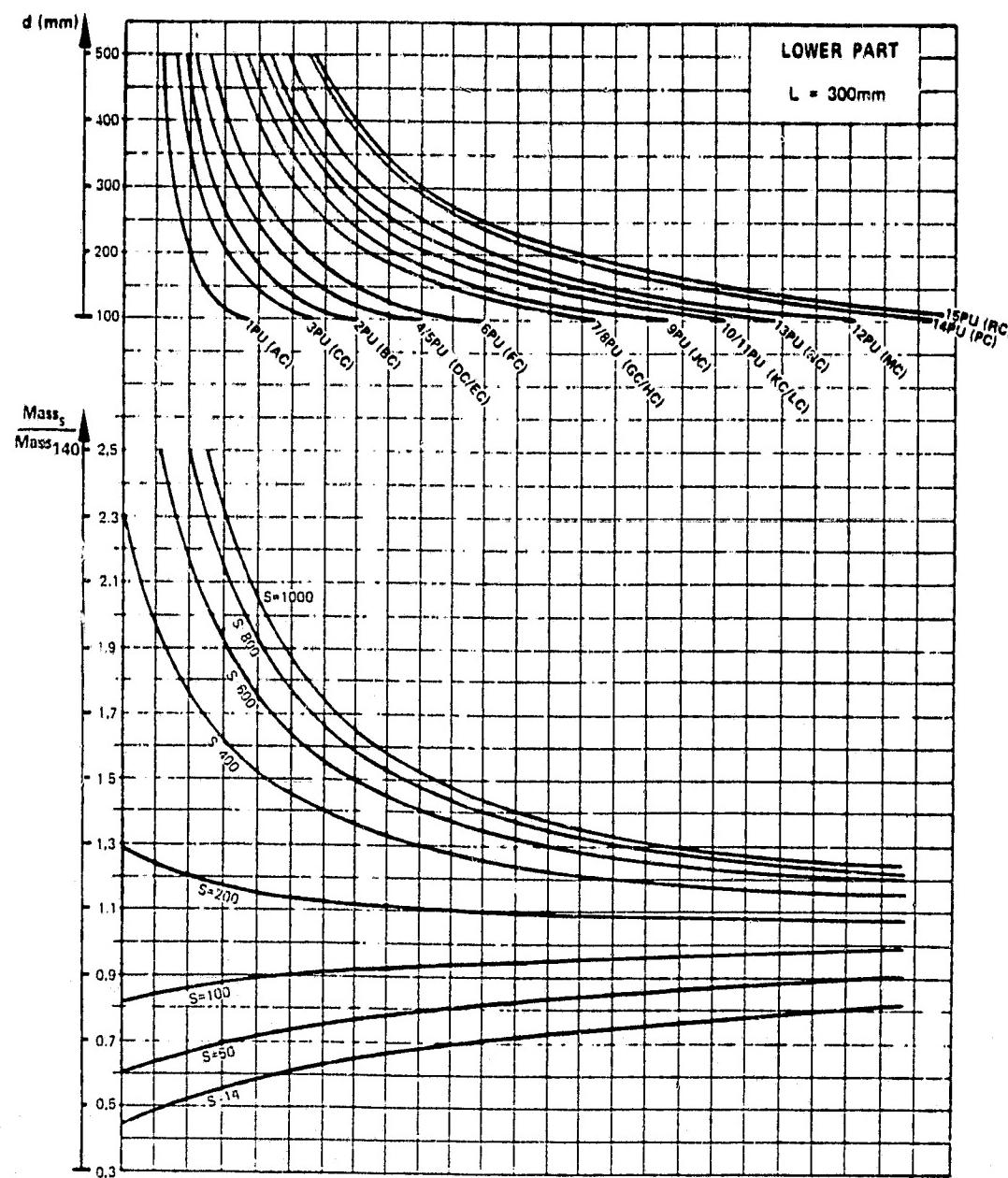
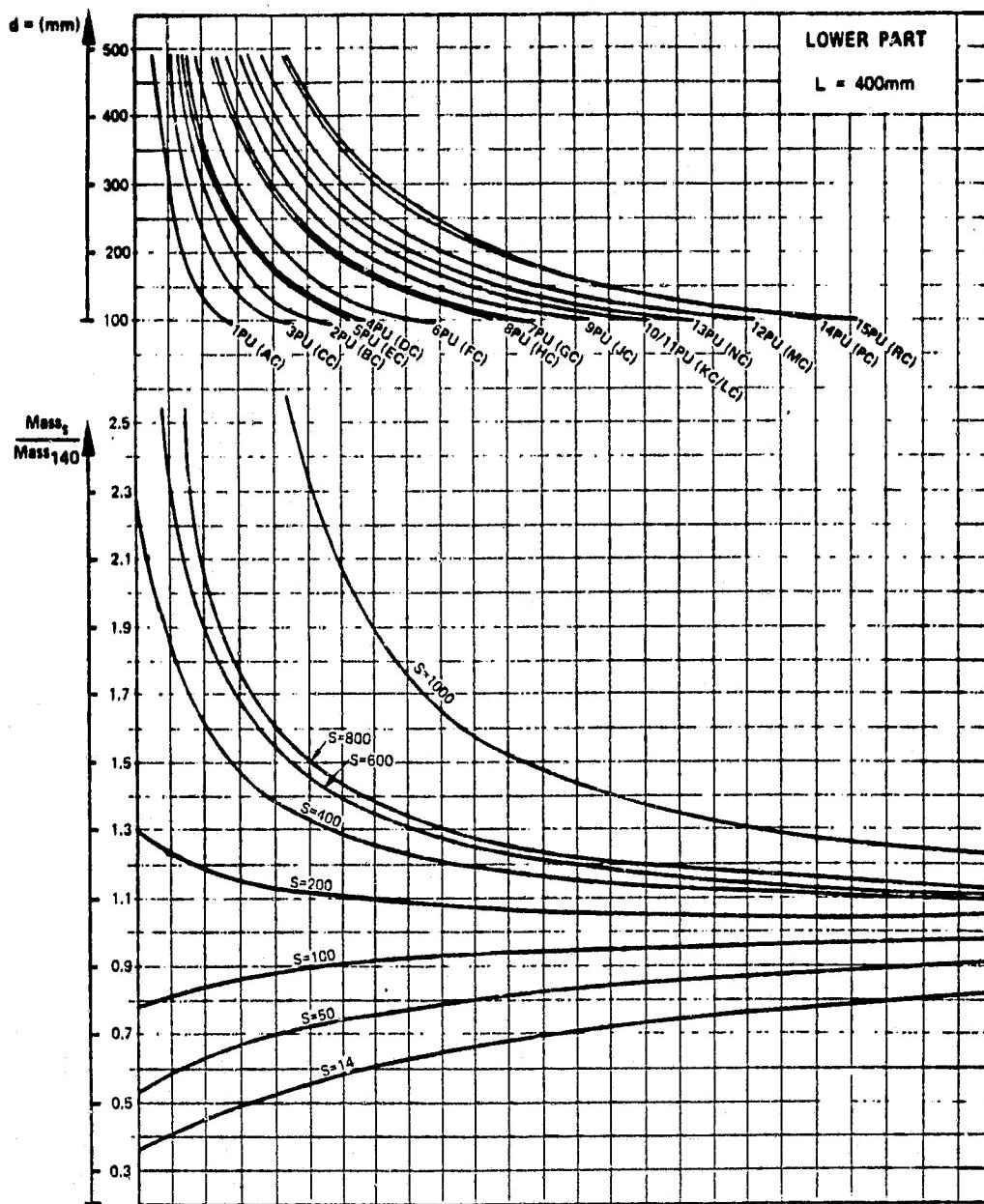


Figure 3.2 - 45d: Rack Load Carrying Capability (Front
Mounted and Back Supported; $S = 140$)

REPRODUCIBILITY OF THE
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Mounted and Back Supported; $S = 140$)

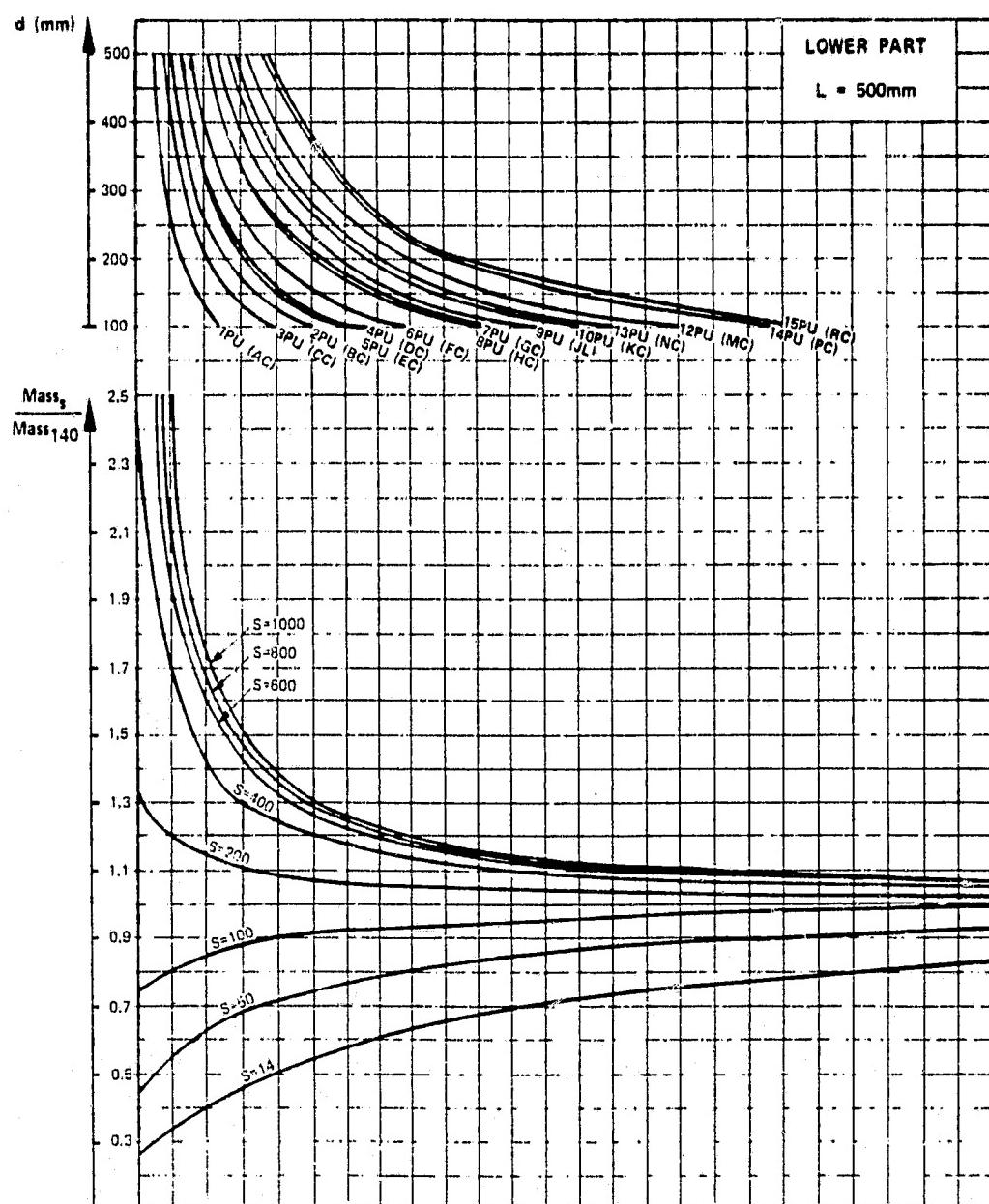


Figure 3.2 - 45f: Rack Load Carrying Capability (Front
Mounted and Back Supported; $S = 140$)

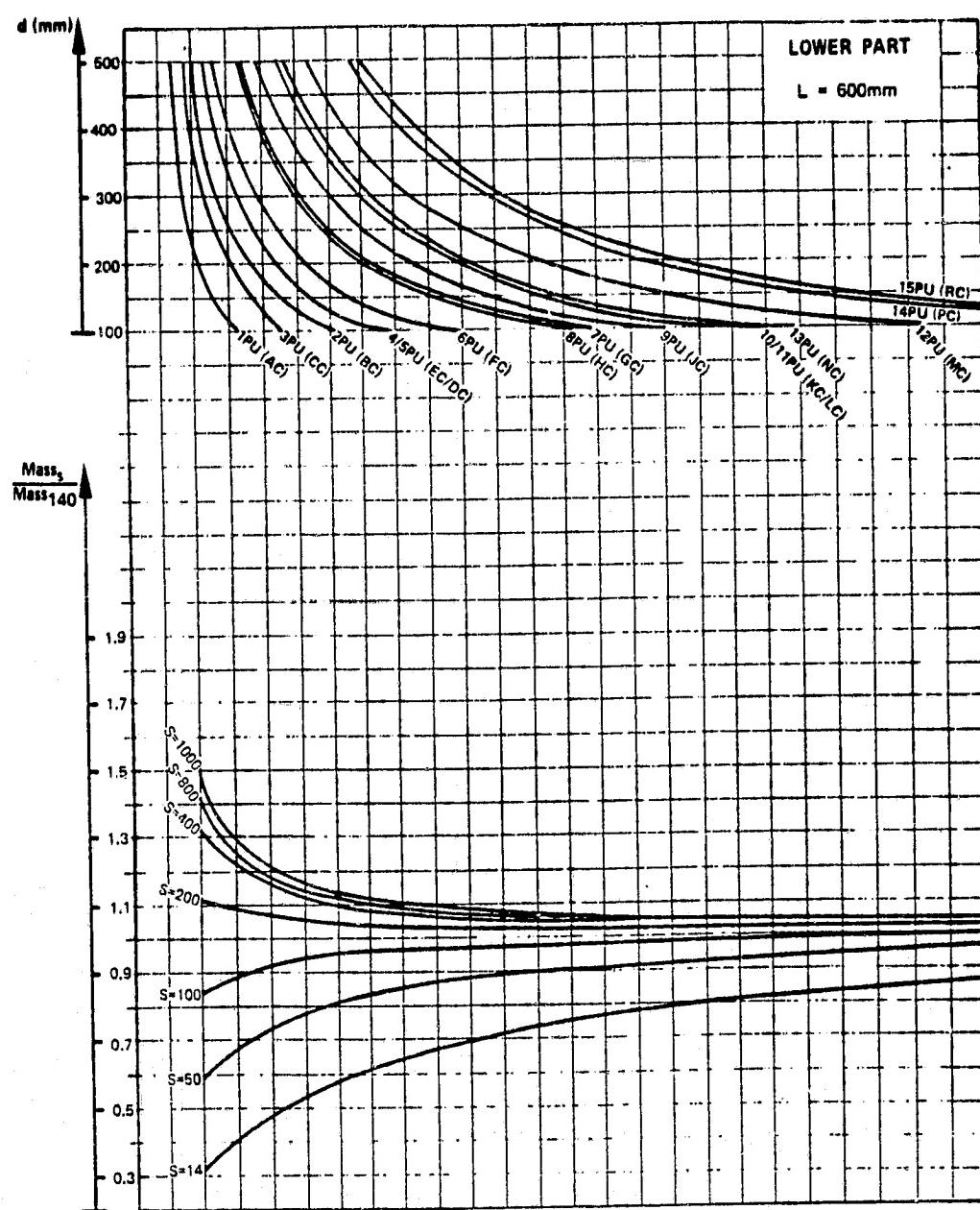
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Figure 3.2 - 45g: Rack Load Carrying Capability (Front
Mounted and Back Supported; $S \neq 140$)

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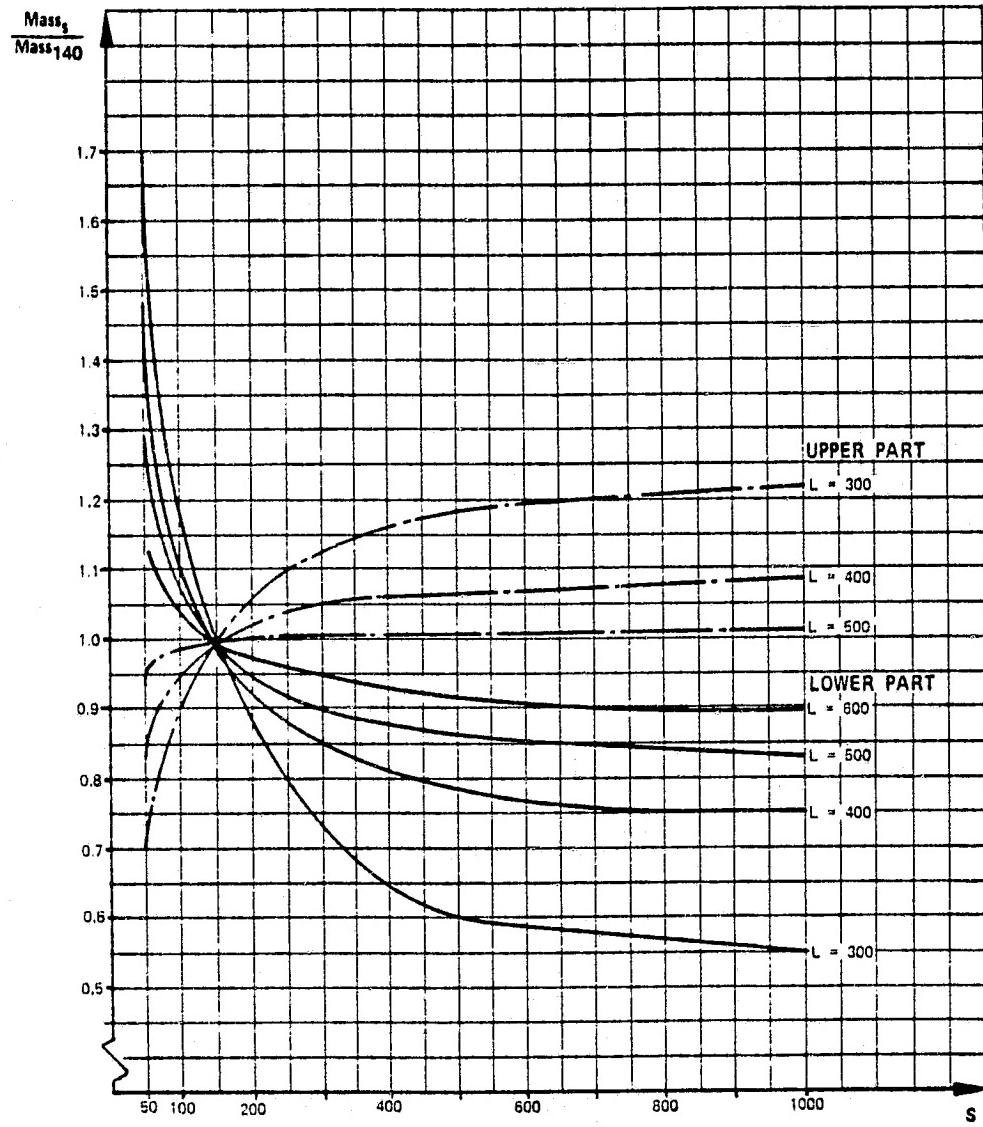
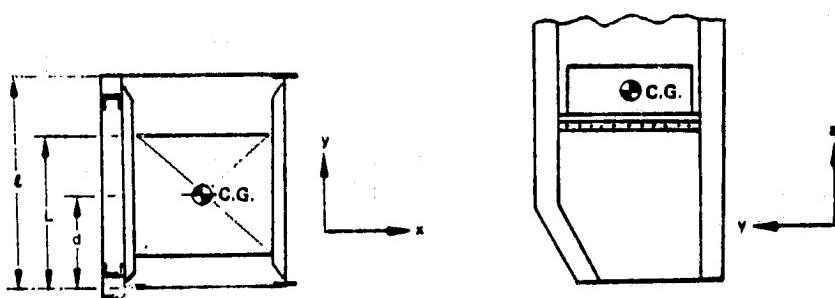


Figure 3.2 - 45h: Rack Load Carrying Capability (Front
Mounted and Back Supported; $S \neq 140$)

3.2.6.2.4

C.G./Mass Limitation for Shelf Mounted Equipment

The rack load carrying capability for shelf mounted equipment is shown in Figure 3.2 - 47 with reference to the parameters given in Figure 3.2 - 46. A further assumption is that the attachments at each corner will be performed by means of single holes.



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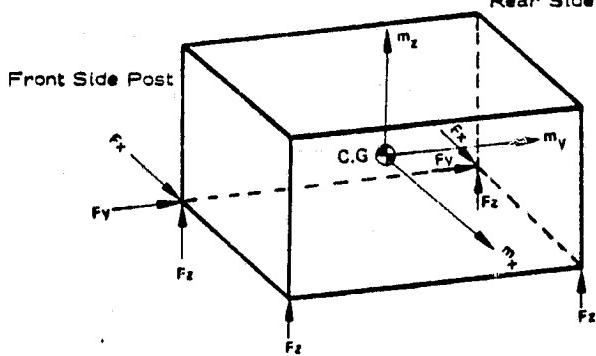


Figure 3.2 - 46: Shelf Mounted Equipment

The load carrying capability of shelves may be considerably increased if multiple hole attachment is possible. Reference is made to the cold plate support structure (CPSS), which is designed for a load of 30 kg (see Figure 3.2 - 28).

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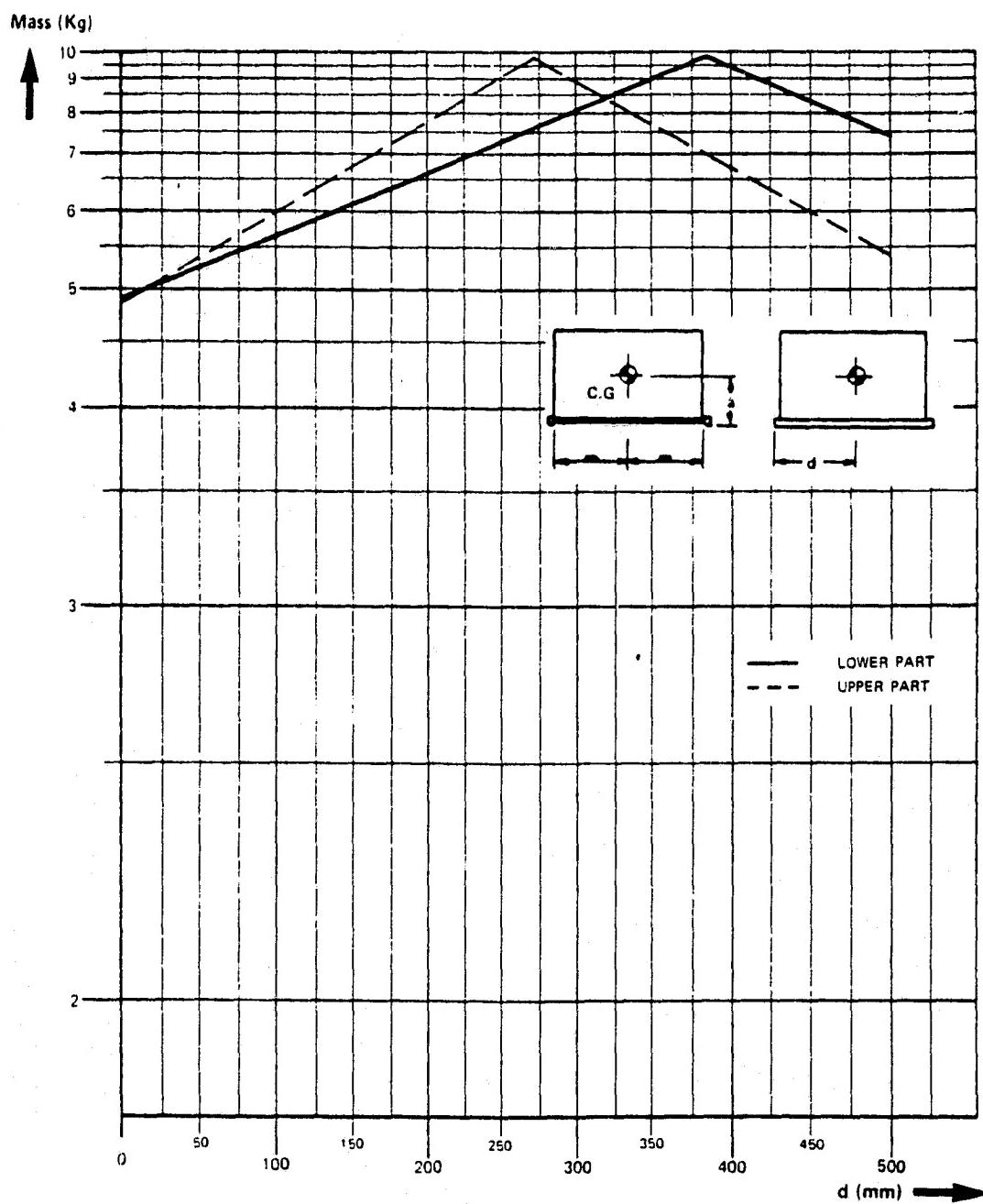


Figure 3.2 - 47 : Rack Load Carrying Capability (Shelf Mounted)

3.2.6.2.5 Alternative Attachment Schemes

As can be deducted from the foregoing, main limitations are dictated by the local standard interfaces. This results in allowable loads which are considerably less than the generally possible overall capability of the rack.

Hence, individual design of load dispersion schemes involving case-by-case analyses may result in considerable improvements. Recommendations for respective designs (see also Figure 3.2 - 48) involve the following modifications:

- utilization of more attachment points on stiff front plate
- implementation of multiple support rails (A)
- design of multiple hole rear support adapters (B)
- structural integration of equipment design

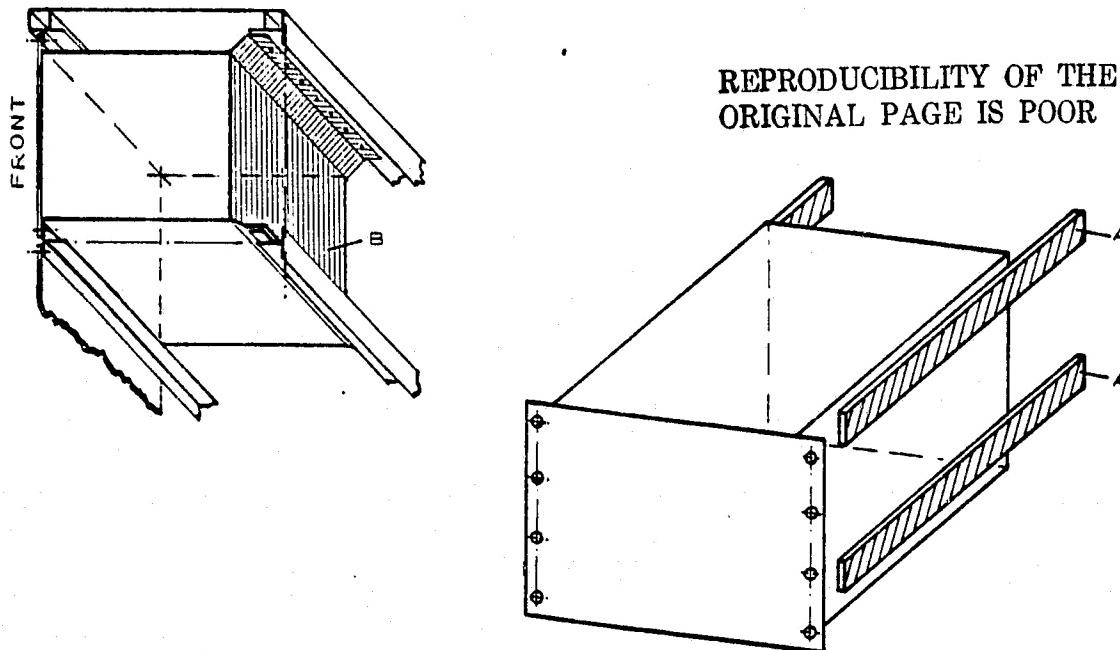


Figure 3.2 - 48: Auxiliary Support Structures

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3.2.7 Mechanical Environment

3.2.7.1 Introduction

This chapter covers the mechanical environment under the general heading "Load Assumption" so as to present a viable guideline to the designer of experiments and applies to all structural areas associated with Appendix B. More detailed information will be found within specific chapters (see table of contents).

3.2.7.1.1 General

Limit load factors are presented for various equipment/experiments mounted at Spacelab primary or secondary structure.

The approach for derivation of these load factors is outlined in HB-ER-002B. The presented limit load factors have to be considered for the dimensioning of

- o brackets of equipment/experiments
- o connection between equipment and bracket
- o connection between bracket and primary or secondary structure
- o primary or secondary structure, influenced by bracketry
- o equipment plus corresponding bracket (box mountings, fasteners) in addition to the test requirements (see para. 7.8 of the main volume of SPAH)

The given limit load factors cover all flight phases from lift-off to landing; however, they do not eliminate the applicability of

- o emergency landing load factors (for pallet mounted experiments only), as discussed in para. 5.1.1.6.1 of SPAH
- o fatigue requirements
- o combinations of mechanical and thermal loads

The defined limit load factors have to be multiplied by the relevant factors of safety, which have to be negotiated between the experimenter and the payload integrator (A minimum value is 1.4 for ultimate and 1.0 for yield). These are dependent on the individual experiment development philosophy and will be defined on request of the experimenter.

For stiffness requirements reference is made to para. 3.1.8.2.3 of this Appendix B.

Designers of equipment/brackets are invited to request special load factors, if

- o the applicability of limit load factors imposes problems
- o the stiffness requirements as per para. 3.1.8.2.3 cannot be met without unacceptable difficulties
- o minimum excitable fundamental frequencies (see para. 3.1.8.2.2) exceed 200 Hz in any direction of the equipment/bracket system

3.2.7.1.2 Application of Limit Load Factor Diagrams

Limit load factors are presented in the following diagrams - "Limit Load Diagrams" - for Spacelab zone "Racks" and "hard-mounted" fundamental frequencies.*²⁾ The term "hard-mounted" implies that a flexible bracket is attached through physical connection elements to the rigid interface plane of the main or secondary structure.

If equipment is mounted without any bracket to the supporting Spacelab structure, those frequencies have to be used, which are expected or which are selected from related tests to yield the most severe internal forces in X-, Y-, and Z-direction with respect to interface reactions.

For using the diagrams the required input parameters are:

- the location ("zone") of Spacelab main or secondary structure to which the bracket is attached (e.g. "Rack", "Pallet Hardpoint")
and
- the minimum hard-mounted fundamental frequencies in X-, Y-, and Z-direction.

Applicable limit load factors can then be taken for the respective equipment mass from the corresponding diagram. Figures 3.1 - 40a and b give the respective values for the zone "Racks".

The indicated limit load factors

- are absolute values $|n|$
- are assumed to act at the equipment/experiment c.g.
- occur simultaneously; hence the most critical combination of limit load factors in X-, Y-, and Z-direction has to be applied for dimensioning.

3.2.7.1.3 Stiffness Requirements

In order to decouple from exciting vehicle dynamic vibrations and to avoid excessive amplitudes of equipment, it is required to keep the "hard - mounted" bracket fundamental frequency above 35 Hz.

The recommended stiffness value is based on the precondition that the design of the interface has been carefully performed, i.e. forces are directly transmitted via stiff members from the bracket to the main or secondary structure. Reduction of bracket mounting stiffness as a result of localized bonding attachments should be carefully avoided.

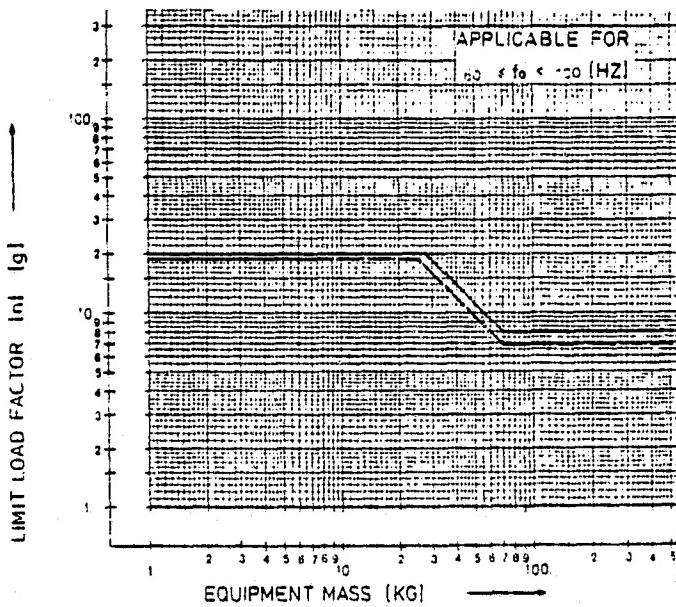
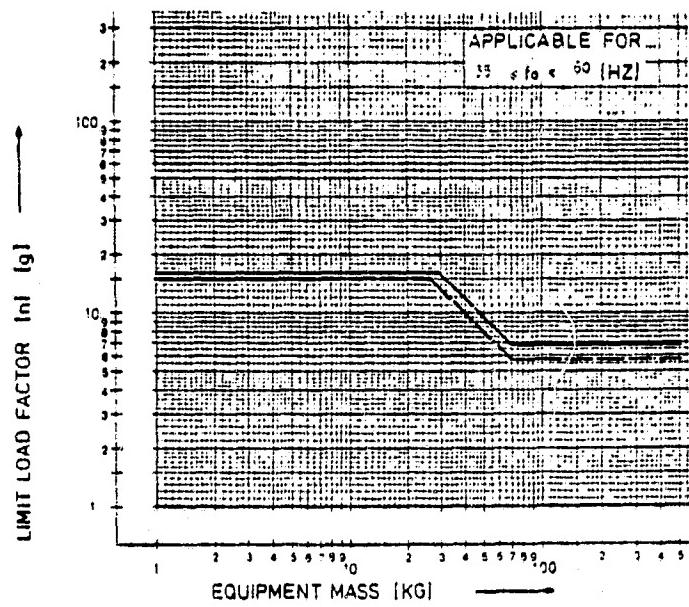
*²⁾ Note: The diagrams of the mechanical environment for other zones will appear at the end of each respective section in this appendix.

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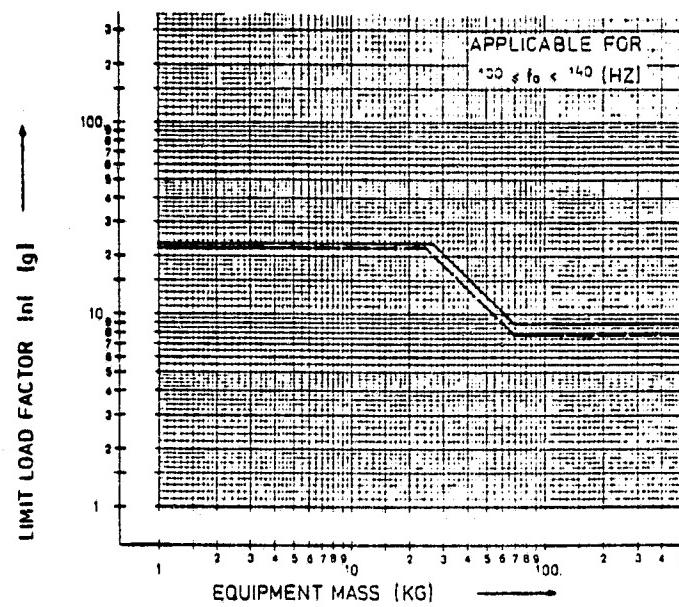
$|n_x|$ —
 $|n_y|$ - - -
 $|n_z|$ - - -

$|n|$ ACTING AT
EQUIPMENT C.G.

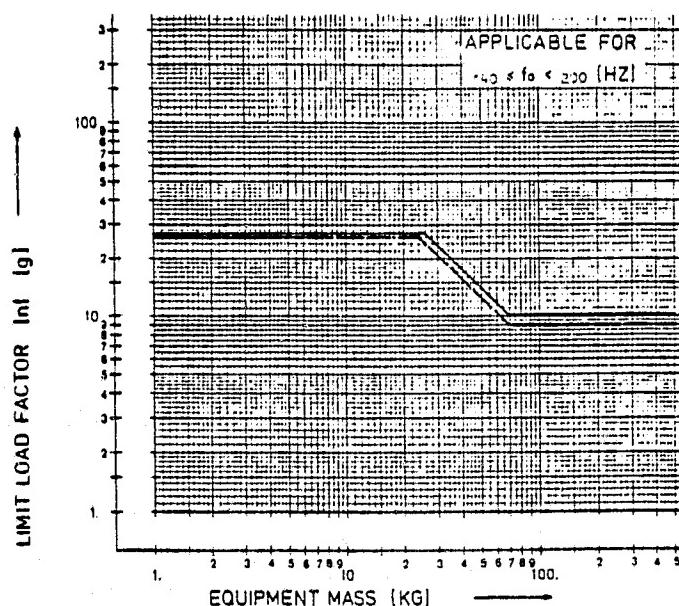
j=1.0

($|n|$ = absolute values)

Figure 3.2 - 49a: Limit Load Factor Diagram for Dimensioning of
Brackets, Zone "Racks"



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$|In_x|$ —
 $|In_y|$ - - -
 $|In_z|$ - - -

$|In|$ ACTING AT
EQUIPMENT C.G.

j=1.0

($|In|$ = absolute values)

Figure 3.2 - 49b: Limit Load Factor Diagram for Dimensioning of
Brackets, Zone "Rack"

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3.3

Module Floor

An overview of the Spacelab module and its floor is given in Figure 3.3 - 1.

The main dimensions of the module floor are given in Figure 3.3 - 2.

Experiment interfaces at the module floor are

- on the center aisle, which provides experiment dedicated interfaces for mechanical attachment, power supply, CDMS, and air cooling
- on the side floor, which is available for experiments if no experiment rack is flown in the respective location. On the side floor the experiment will make use of the interface primarily foreseen for the experiment racks
- In the underfloor of the experiment segment of the module (long module configurations only) The experiment interfaces in the underfloor area are identical to the interfaces for the subfloor in the core segment.

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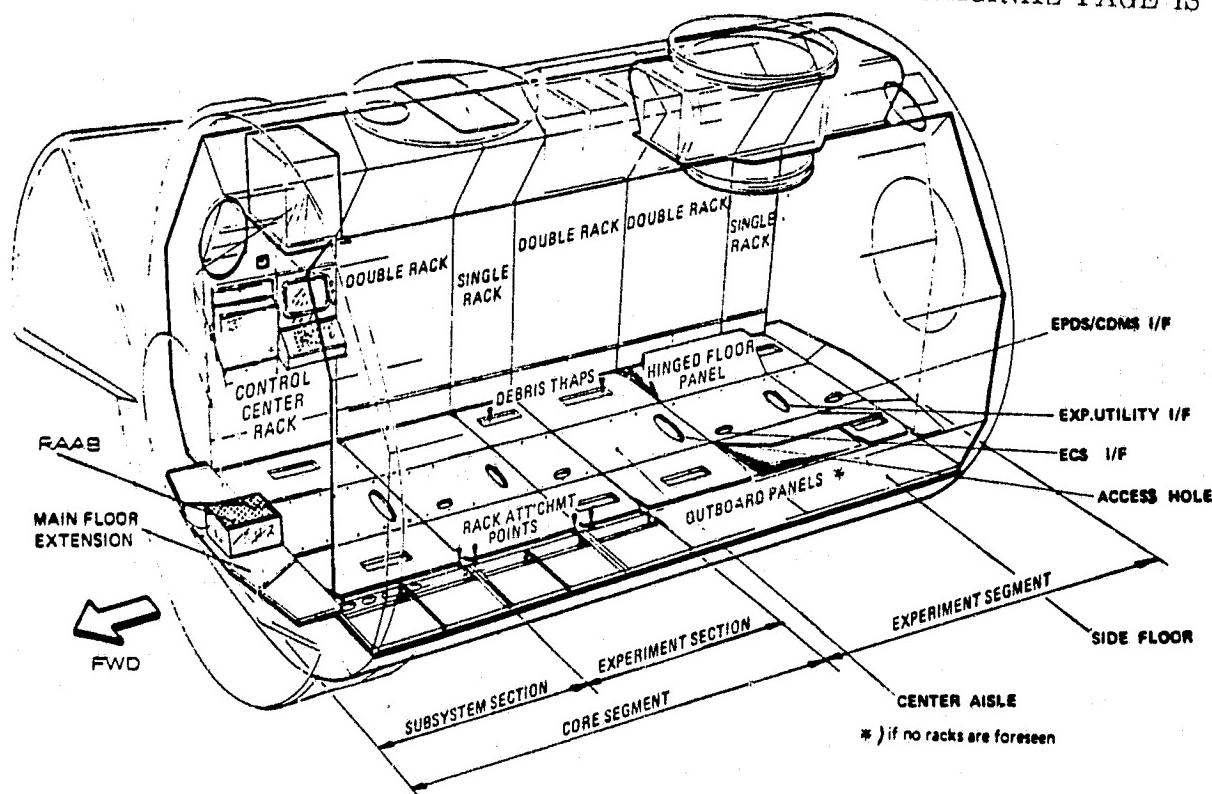
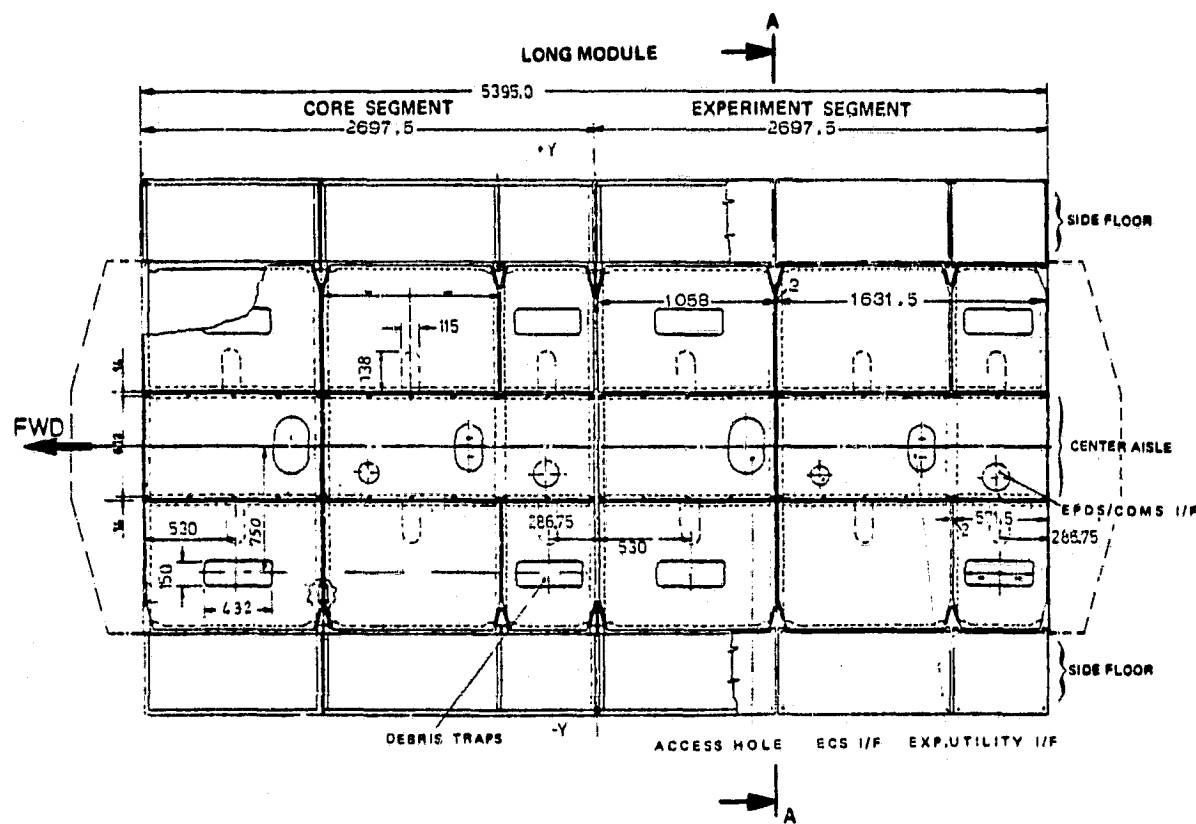


Figure 3.3 - 1 : Module Floor - Overview

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SECTION A-A
TURNED 90°

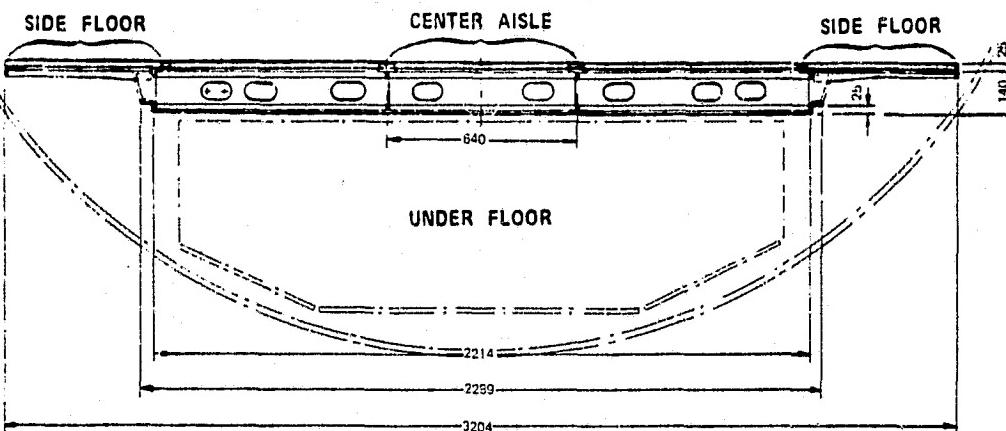


Figure 3.3 - 2 : Floor Planview and Section

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3.3.1 Center Aisle

3.3.1.1 Center Aisle Usable Envelope

The usable envelope for experiment equipment in the center aisle is shown in Figure 3.3 - 3a and 3.3 - 3b for the short and long module.

Access requirements to Spacelab subsystem equipment on the subfloor impose constraints for the use of the dotted volume in the subsystem section of the module.

However, the detailed constraints are TBD.

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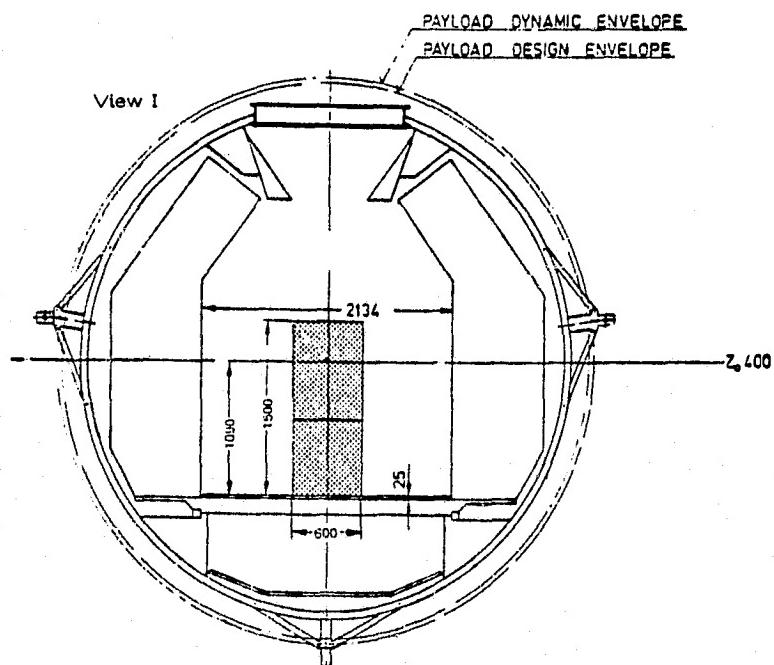
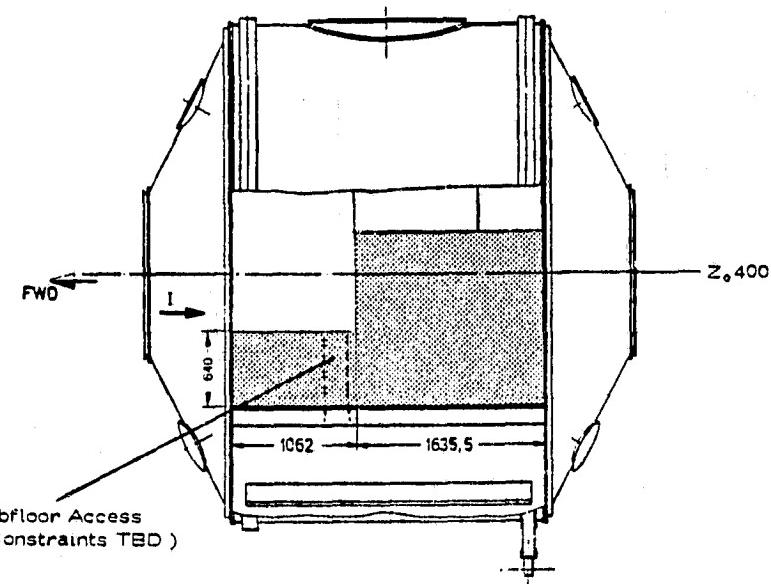


Figure 3.3 - 3a : Center Aisle Envelope-Short Module.

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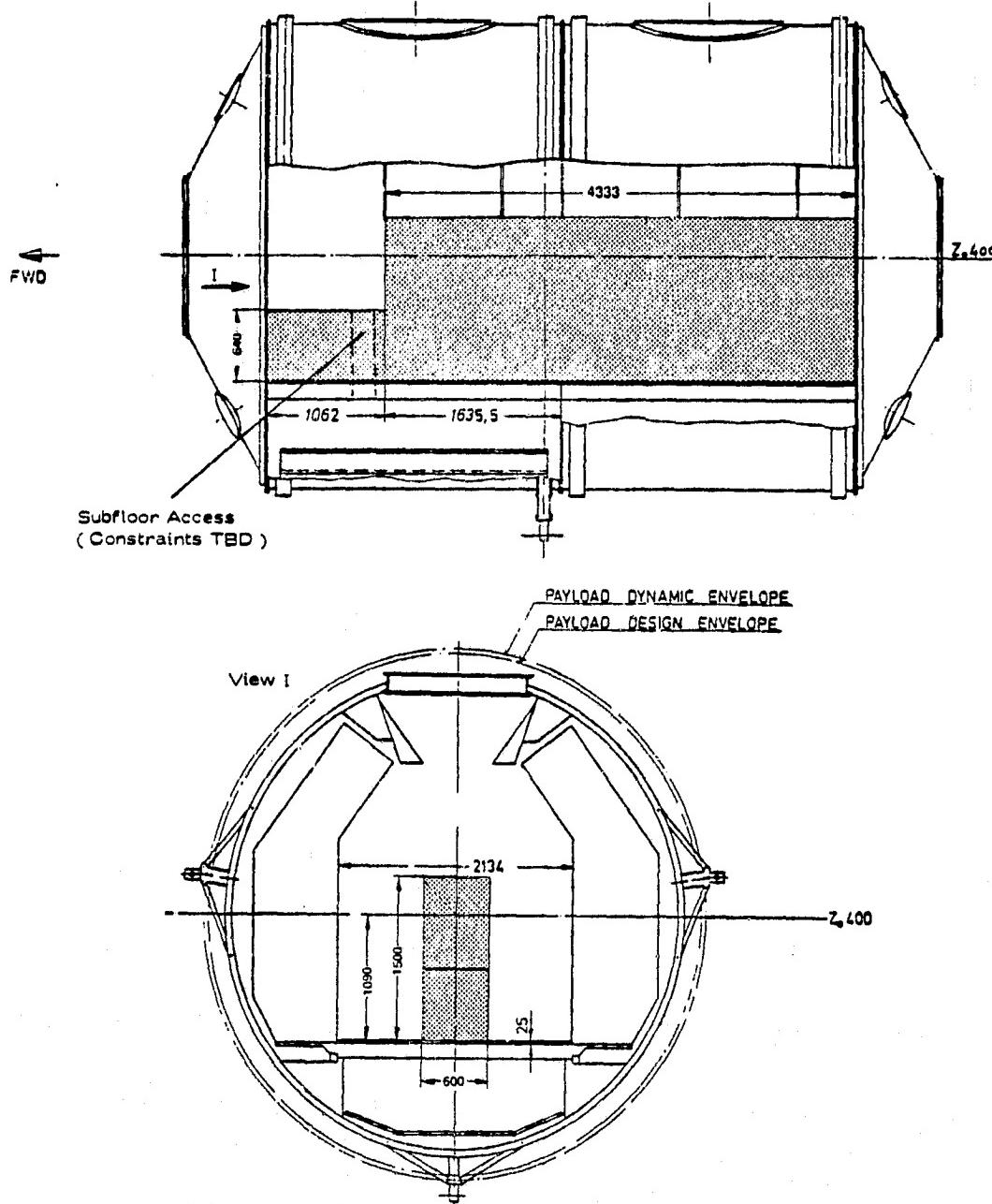
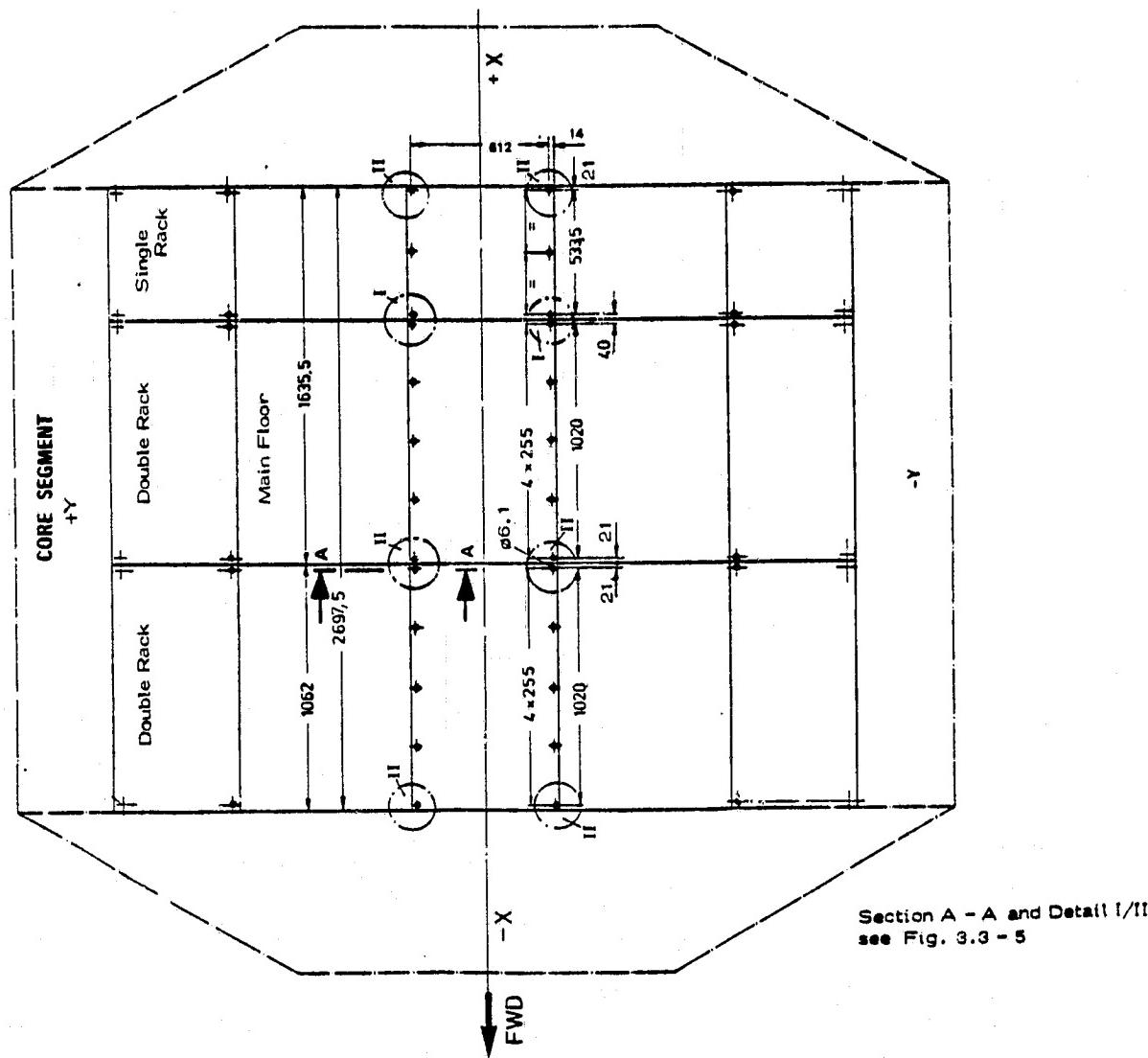


Figure 3.3 - 3b : Center Aisle Envelope - Long Module.

3.3.1.2 Center Aisle Mechanical Interface

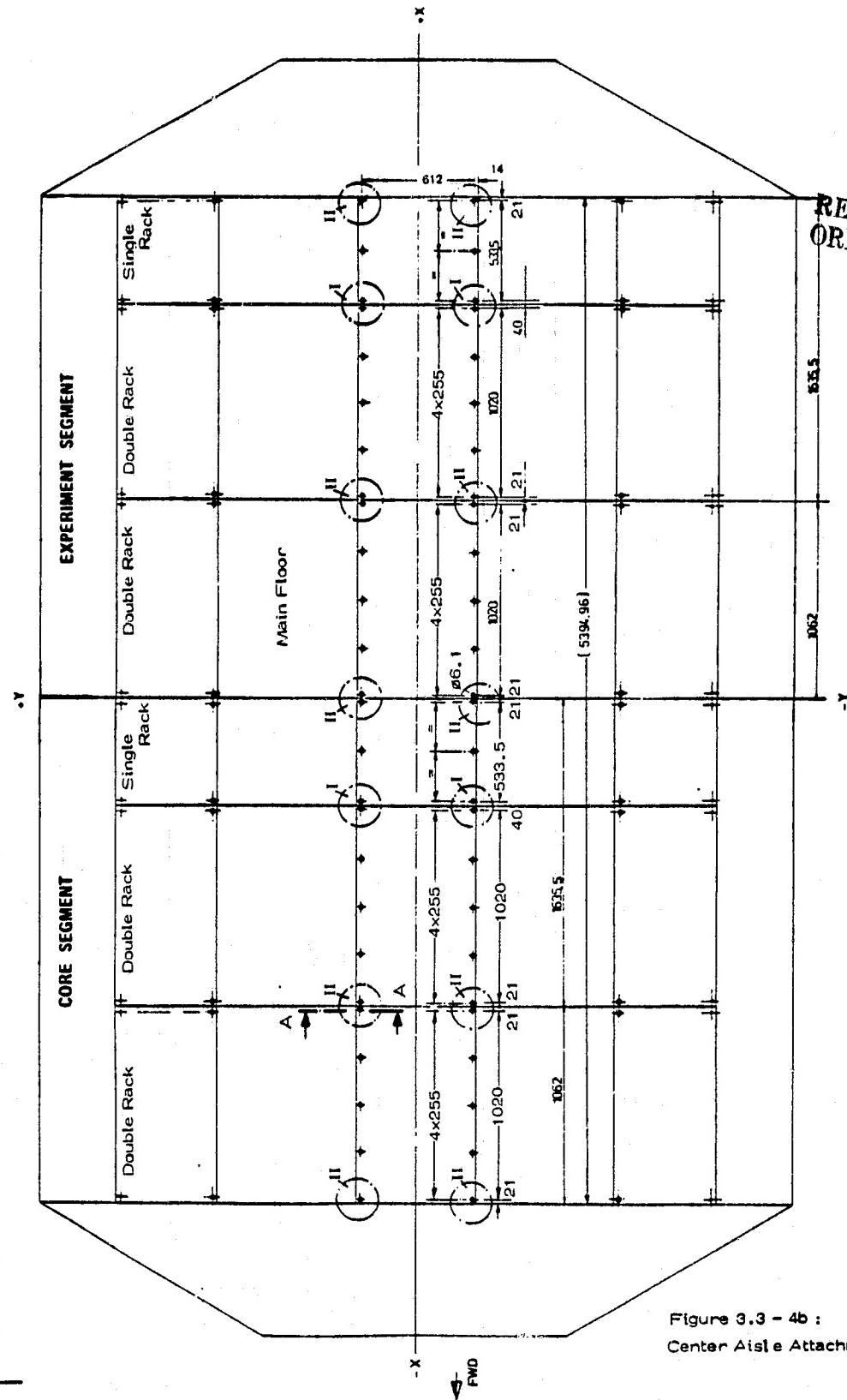
The locations of the experiment attachment points in the center aisle are given in Figure 3.3 - 4a and 3.3 - 4b for the short and long module.



Interface for payload accommodation in circles.

Additional holes may be only used to facilitate experiment installation on the ground.

Figure 3.3 - 4a : Center Aisle Attachment - Short Module



Section A - A and Detail I/I see Fig. 3.3 - 5

Interface for payload accommodation in circles.

Additional holes may be only used to facilitate experiment installation on the ground.

Figure 3.3 - 4b :
Center Aisle Attachment - Long Module

The detailed mechanical interface for the attachment of center aisle equipment is given in Figure 3.3 - 5. The attachment provisions are basically holes through fixed floor panels and floor beam structure for experiment provided M6 bolts.

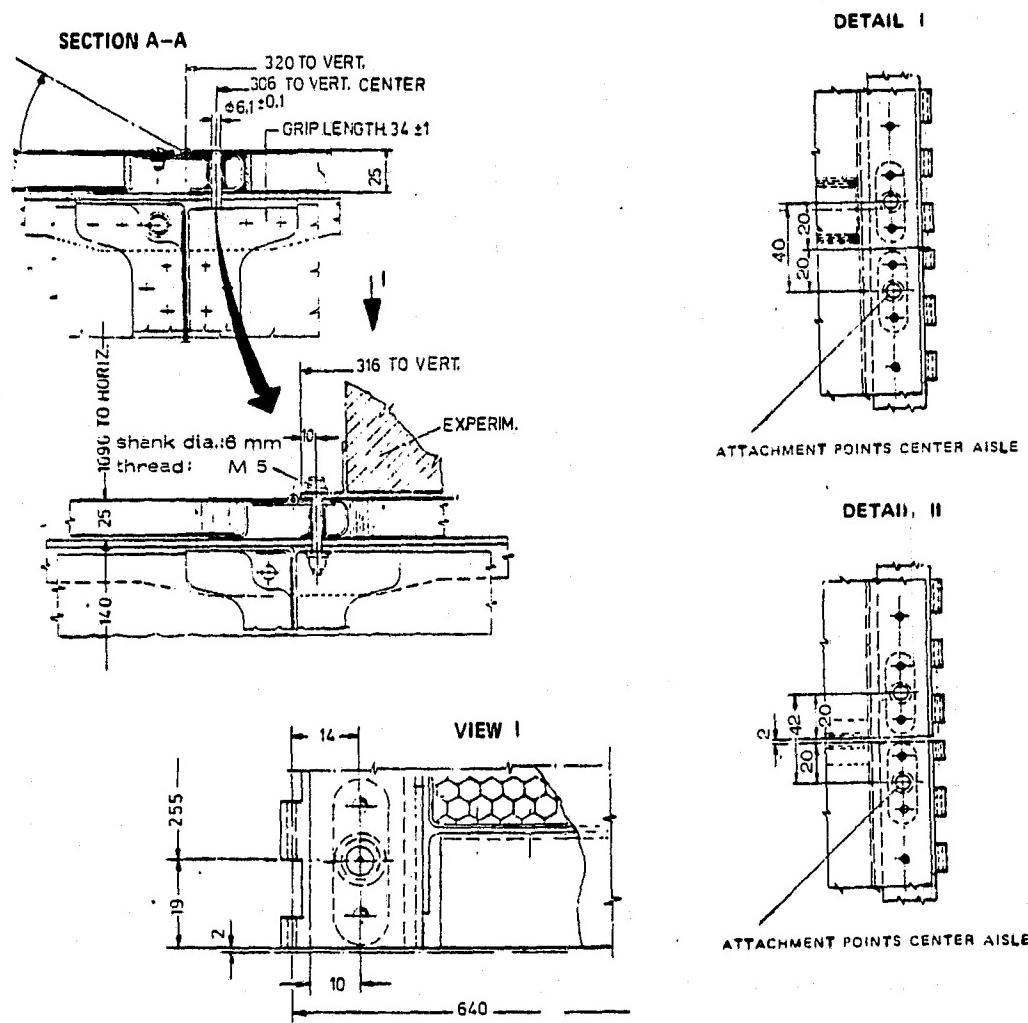
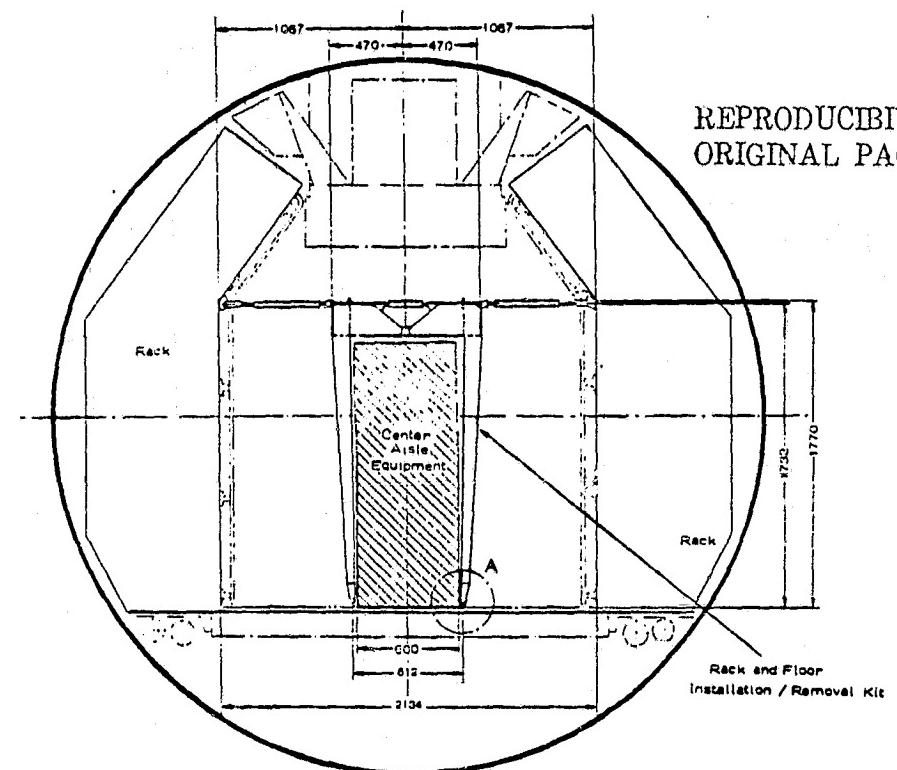


Figure 3.3 - 5 : Floor Attachments - Details

During ground operation the experiment attachment points in the center aisle are also used for the MGSE Item Rack and Floor Installation Removal Kit as shown in Figure 3.3 - 6. Therefore the experiment attachment brackets have to be designed such that the MGSE feet can be mounted on top of the experiment brackets as shown in Figure 3.3 - 7a and 3.3 - 7b.



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Detail "A", see Fig. 3.3 - 7a/b

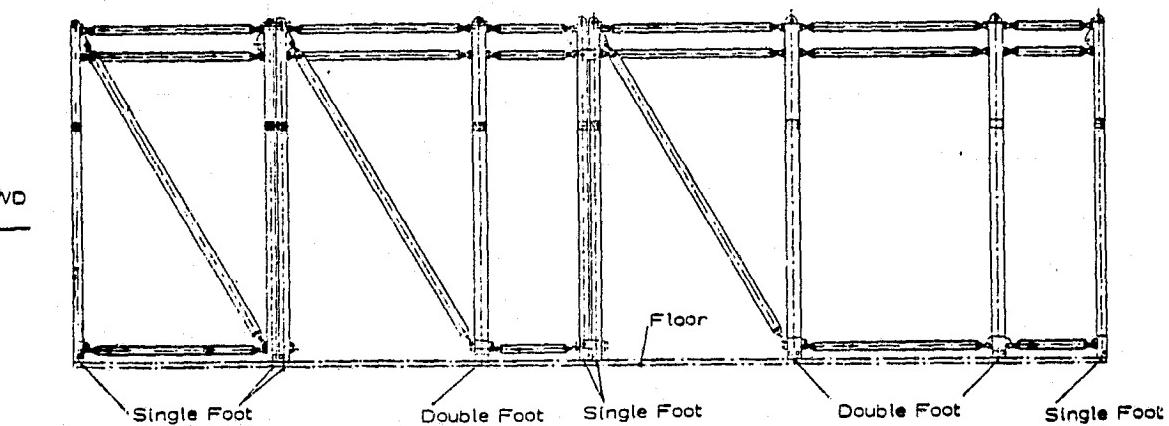
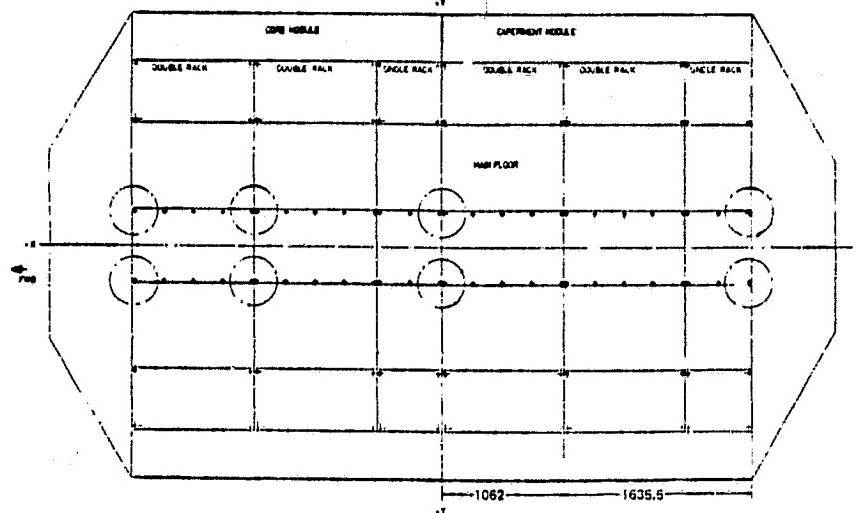


Figure 3.3 - 6 : Rack MGSE-Overview

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Single Foot Location

Detail: "A"

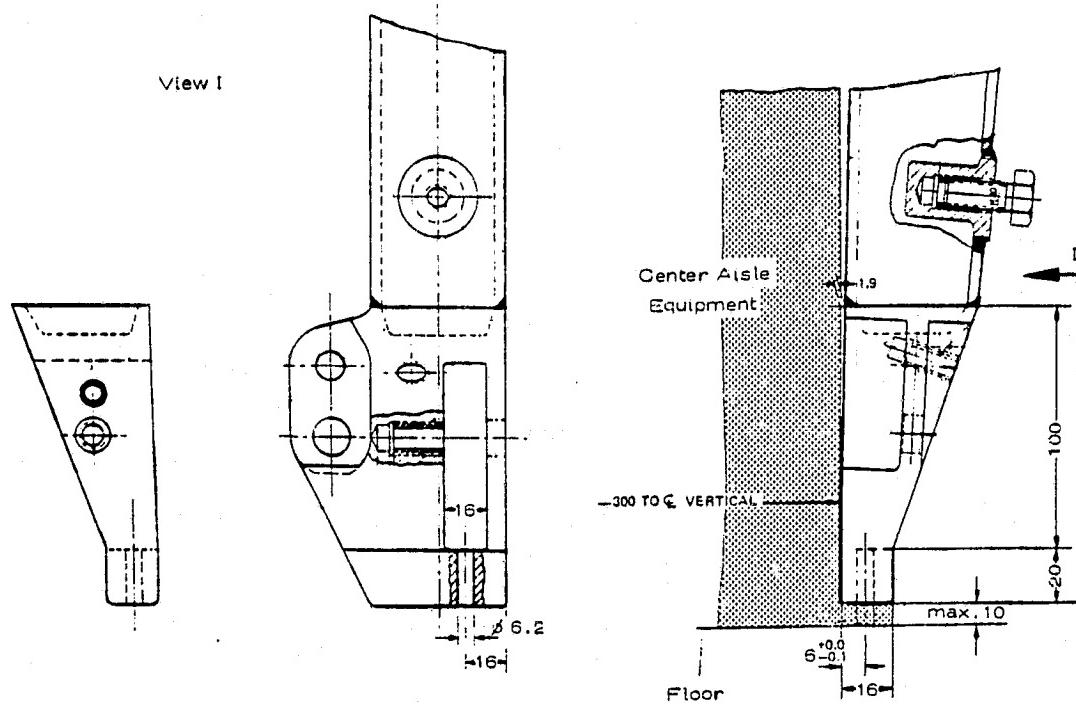
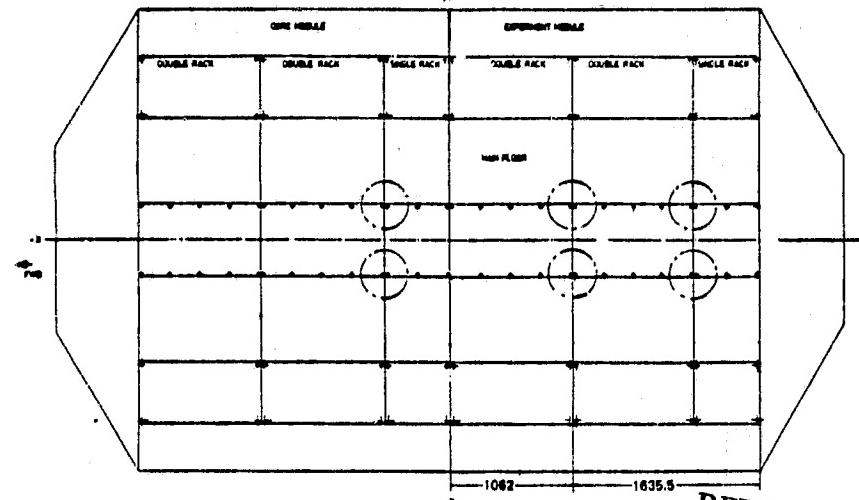


Figure 3.3 - 7a : MGSE-Single Foot



Double Foot Location

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Detail: "A"

View II

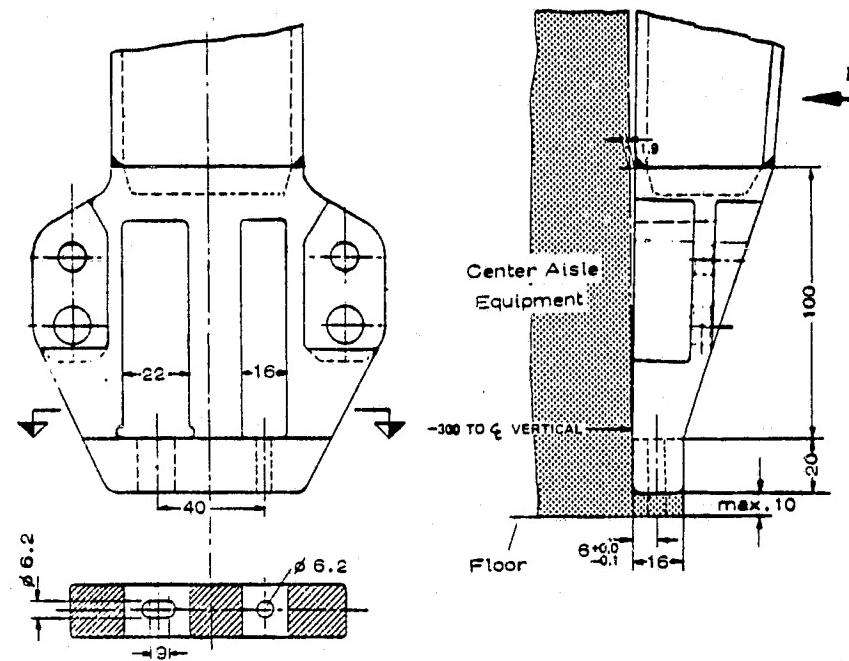


Figure 3.3 - 7b : MGSE-Double Foot

3.3.1.3 Center Aisle Cut-outs

Figure 3.3 - 8 shows the locations of cut-outs in the center aisle which provide for

- EPDS/CDMS Interface i.e. connector bracket which provides power and support for an experiment RAU
- ECS interface i.e. cut-out for cabin loop air flow through center aisle equipment
- Experiment Utility interface i.e. cut-out with attachment provisions for experiment provided connector bracket
- Access hole for access to subsystems in core segment and access to experiment equipment in experiment segment underfloor area.

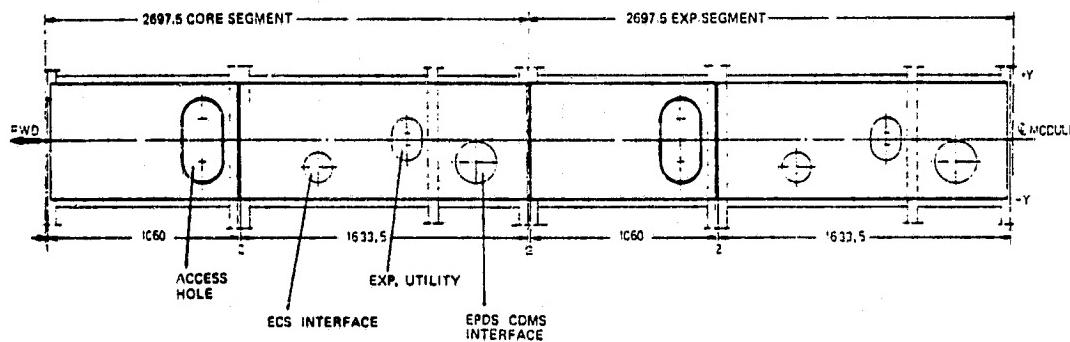
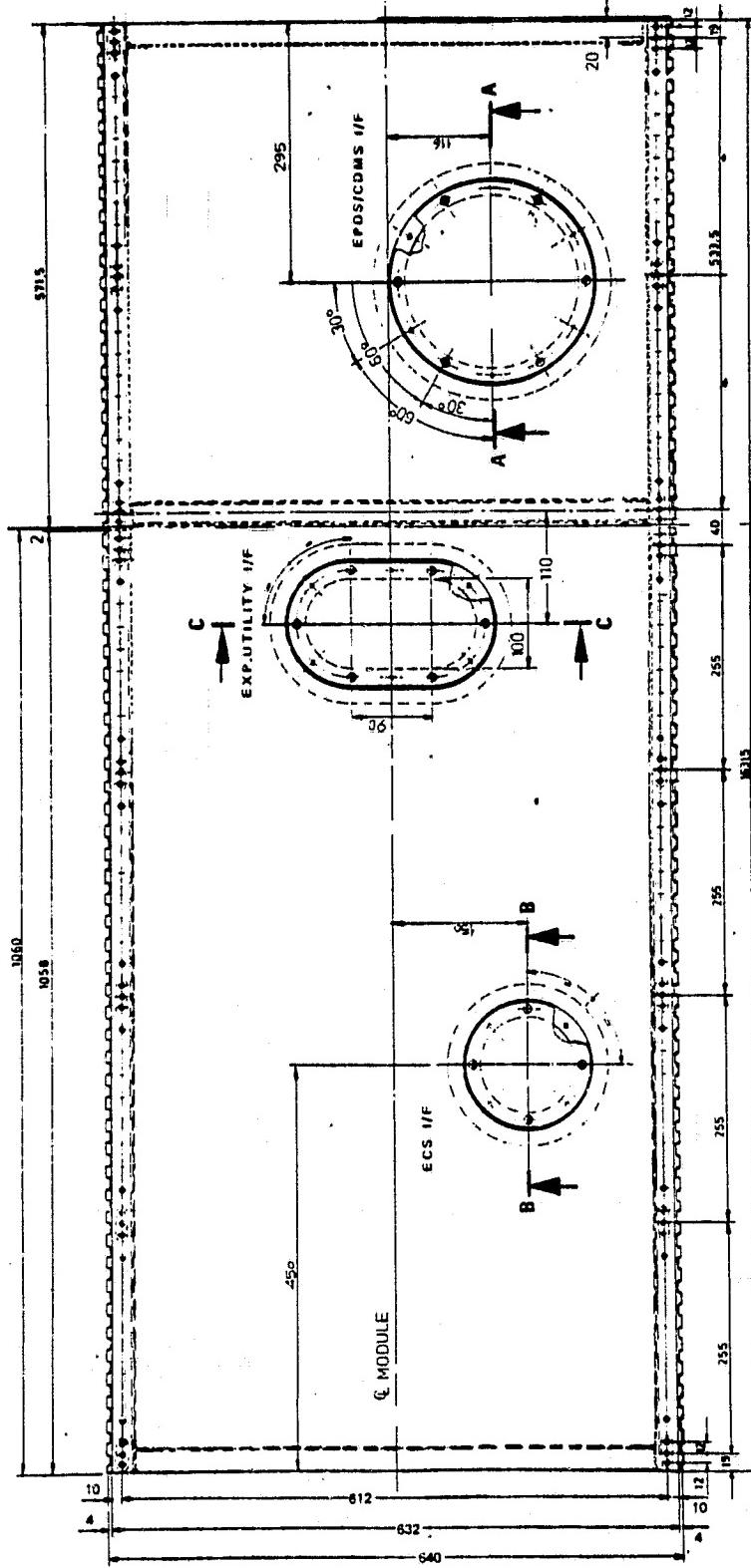


Figure 3.3 - 8a : Center Aisle Interfaces - Overview

Payload attachment interfaces see also Fig. 3.3 – 4a/b



B 3.3 - 13

Section A - A see Fig. 3.3 - 9a

Section B - B see Fig. 3.3 - 9b

Section C - C see Fig. 3.3 - 9c

Figure 3-3 – #b : Center Aisle Interfaces = Definition

3.3.1.3.1

EPDS/CDMS Interface

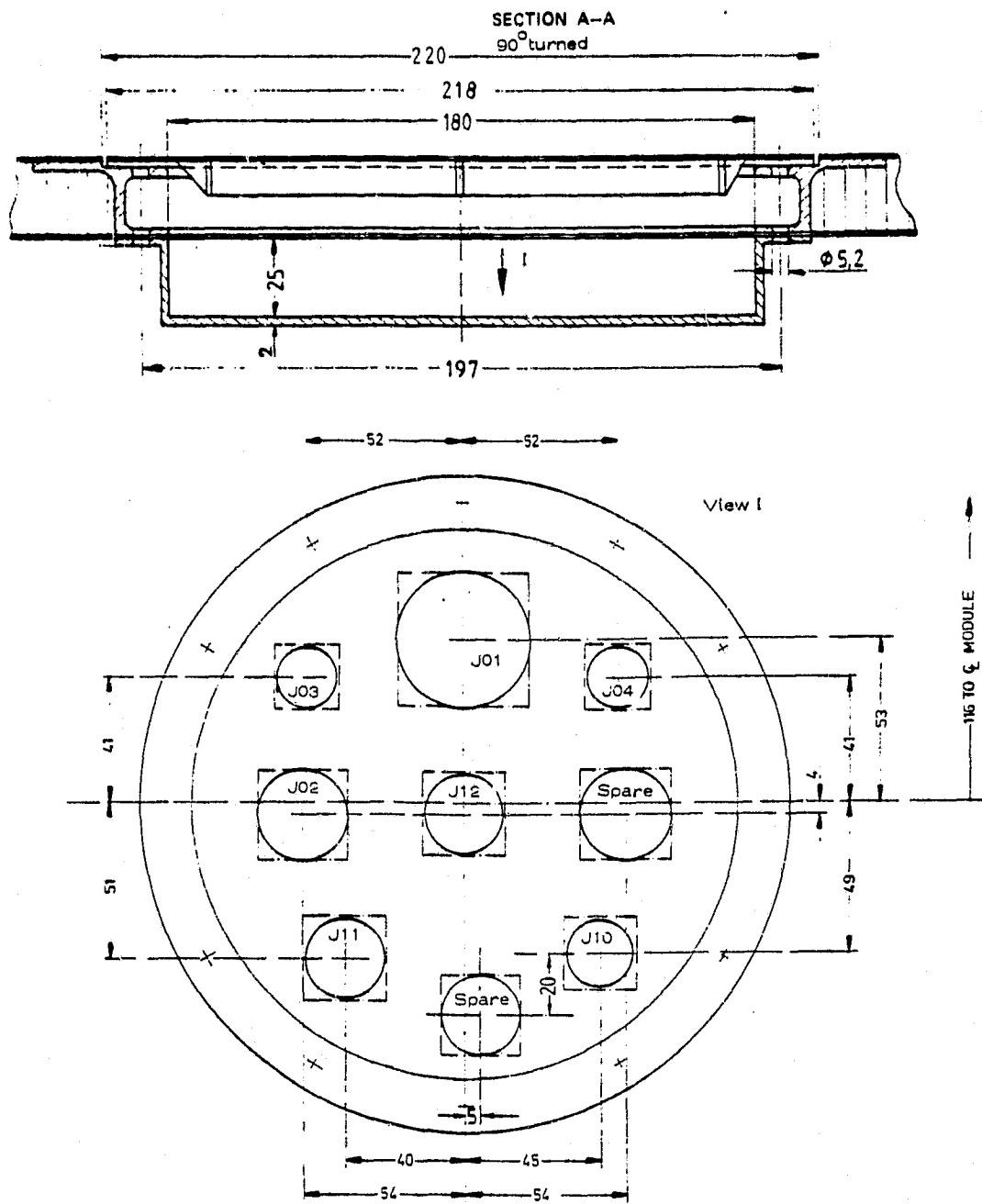


Figure 3.3 - 2a : Center Aisle CB 31(32)

The notation of the EPDS/CDMS interface center aisle connector brackets is

- CB 31 in the core segment
- CB 32 in the exp. segment

The connector/pin allocation and the electrical interface characteristics are defined in Section 3.5 of Appendix A.

3.3.1.3.2

ECS Interface

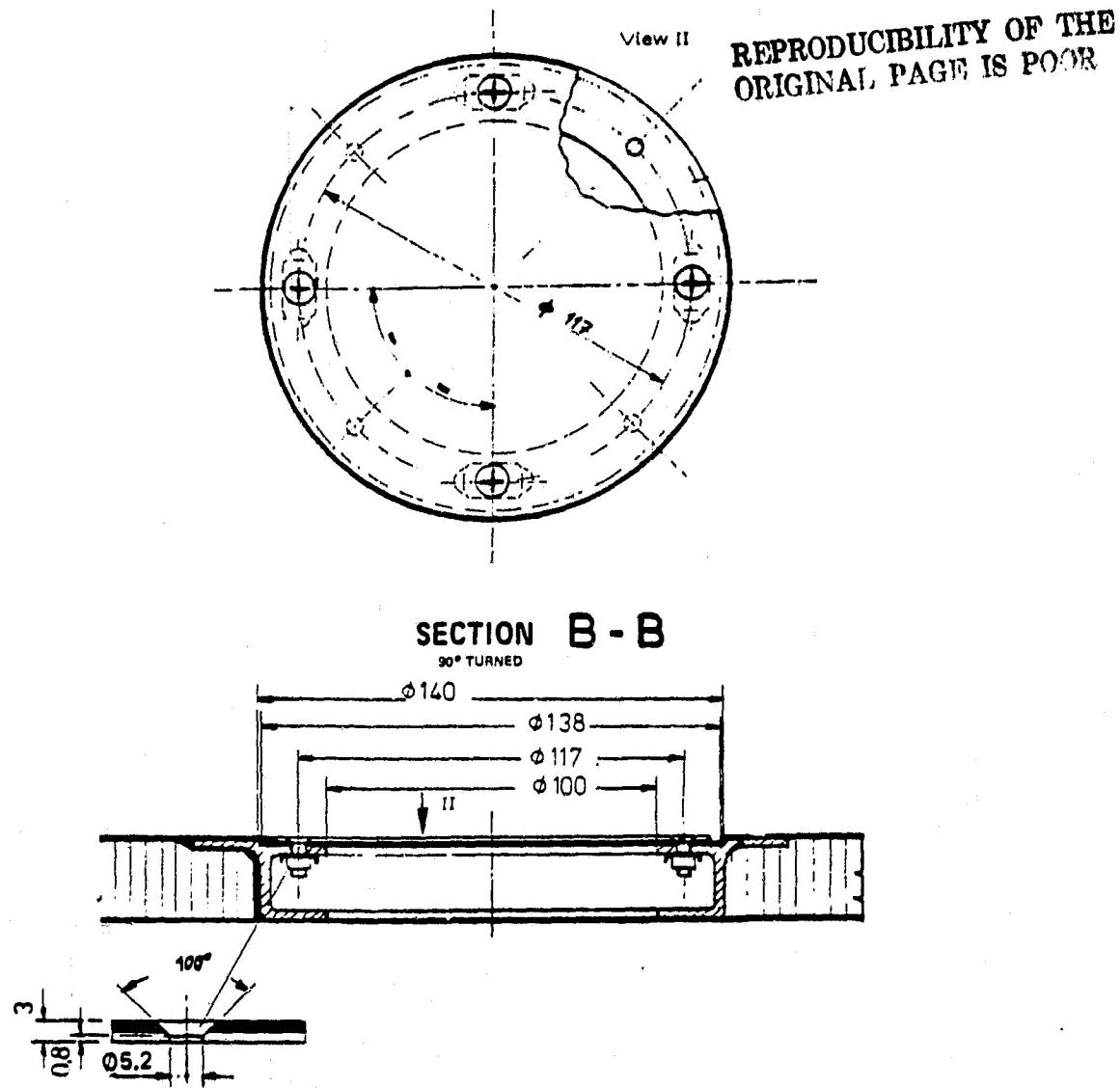


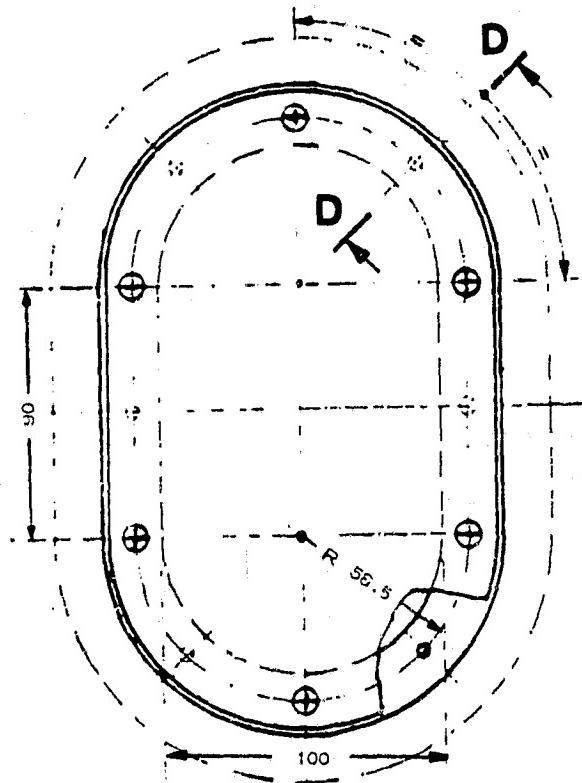
Figure 3.3 - 9b : ECS Interface

The thermal requirements and constraints for the use of this ECS interface will be defined in section TBD or Appendix C.

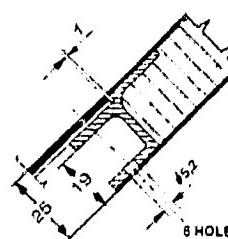
3.3.1.3.3

Experiment Utility Interface

View III



SECTION D-D



6 HOLES FOR EXPERIMENTER PROVIDED
CONNECTOR BRACKET

SECTION C-C'

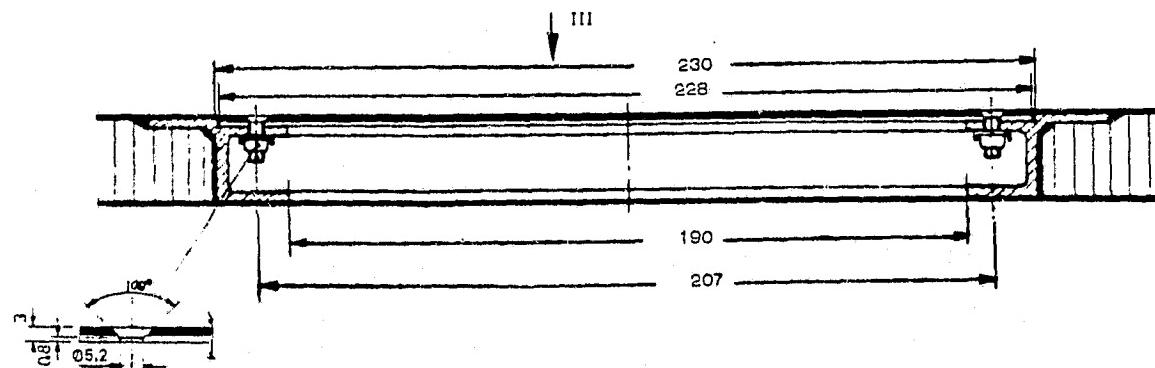


Figure 3.3 - 9c : Utility Routing Provision

The connector bracket to be attached to this cut-out has to be provided by the experimenter/payload integrator with connectors, feedthroughs and fittings determined by the actual payload.

The connector bracket should be similar to that shown in 3.3.1.3.1.

3.3.1.3.4

Access hole

In the core segment the access hole is to provide access to Spacelab subsystems on the subfloor.
Constraints for experiments to prevent blockage of this access hole are defined in section 3.3.1.1.

In the experiment segment the access hole provides access to the underfloor area which is available
for experiments.

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Payload attachment interfaces see also Fig. 3.3 - 4a/b

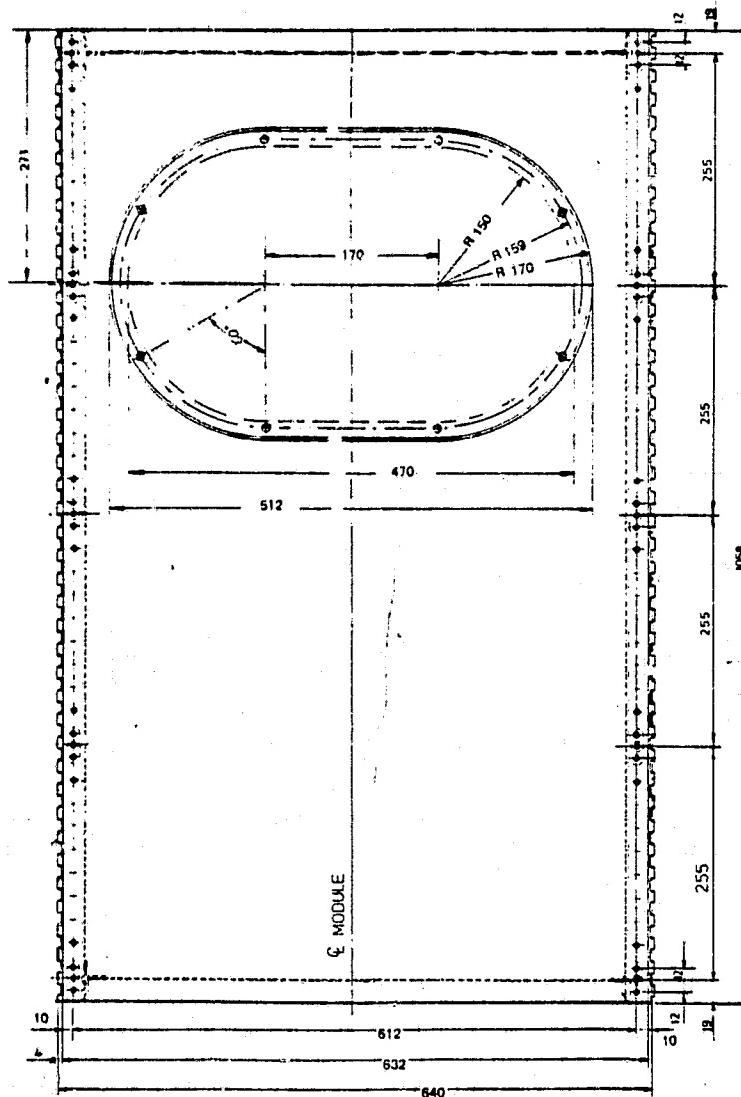
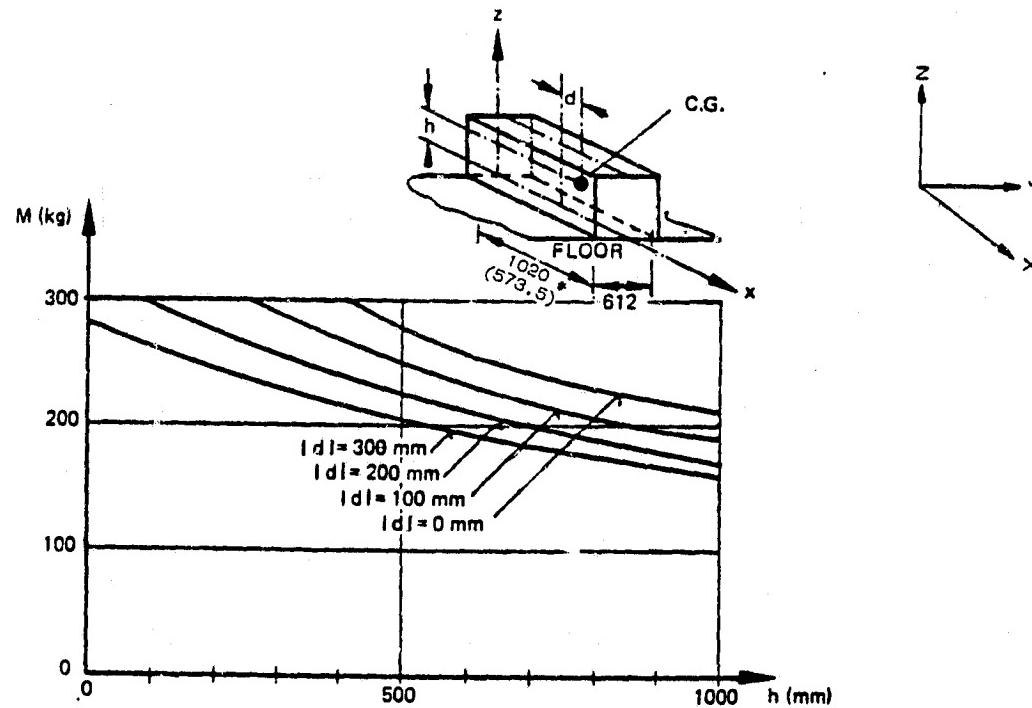


Figure 3.3 - 9d : Center Access Hole

3.3.1.4 Center Aisle Load Carrying Capability

3.3.1.4.1 Overall Load Carrying Capability

The design load carrying capability is 300 kg/m. The limitations due to various c.g. locations are given in Figure 3.3 - 10. They are applicable for all floor frame segments (see also Fig. 3.3 - 4a and 3.3 - 4b). The limitations in y - direction will be supplied in a later issue.



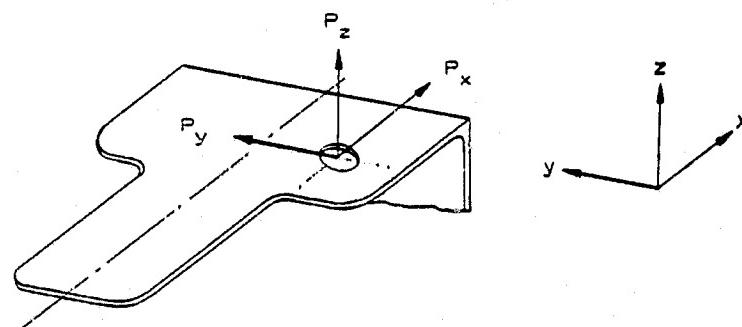
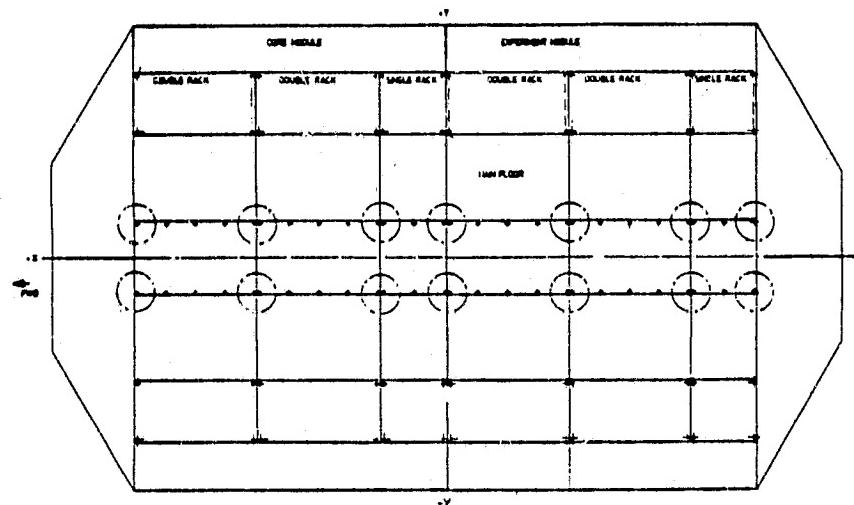
* hardpoint dimensions are shown. Floor frame segment length 1062 (573.5)

Figure 3.3 - 10 : Module Floor Load Carrying Capability Limitations

3.3.1.4.2

Local Loads

The ultimate allowable loads for a single center aisle attachment point are given in Figure 3.3 - 11.



$$P_x = \pm 2451 \text{ N}$$

$$P_y = \pm 1785 \text{ N}$$

$$P_z = \pm 6668 \text{ N}$$

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Interface for payload accommodation in circles.

Additional holes may be only used to facilitate experiment installation on the ground.

Figure 3.3 - 11 : Max. Combined Local Interface Loads of Center Aisle Attachments

3.3.1.5 Mechanical Environment

3.3.1.5.1 Floor Attachment Point Mechanical Environment

The mechanical environment for the center aisle attachment points is given in Figure 3.3 - 12a and 12b.

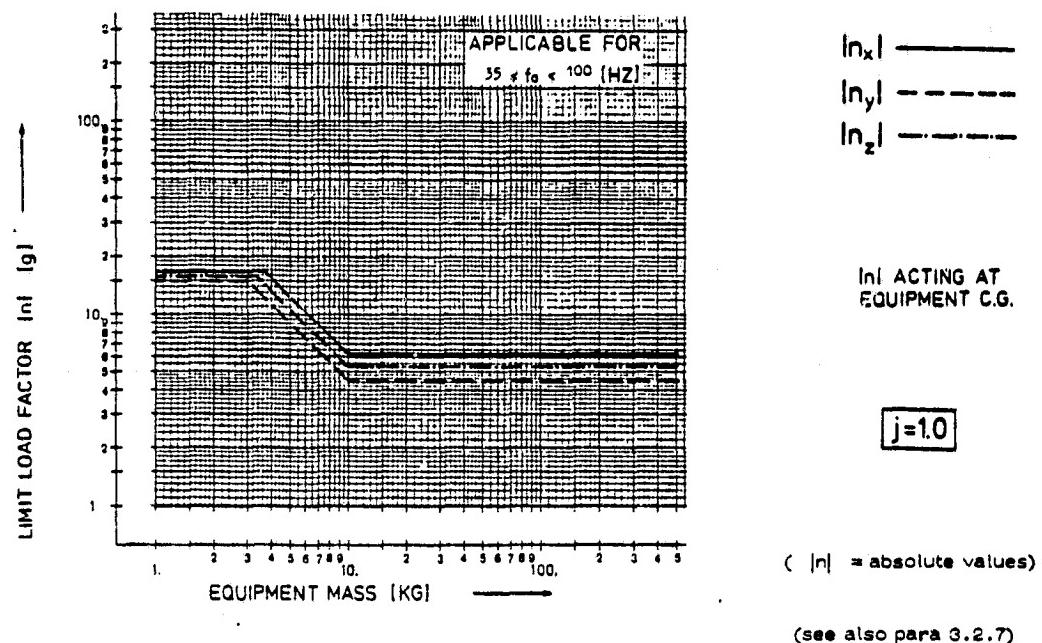
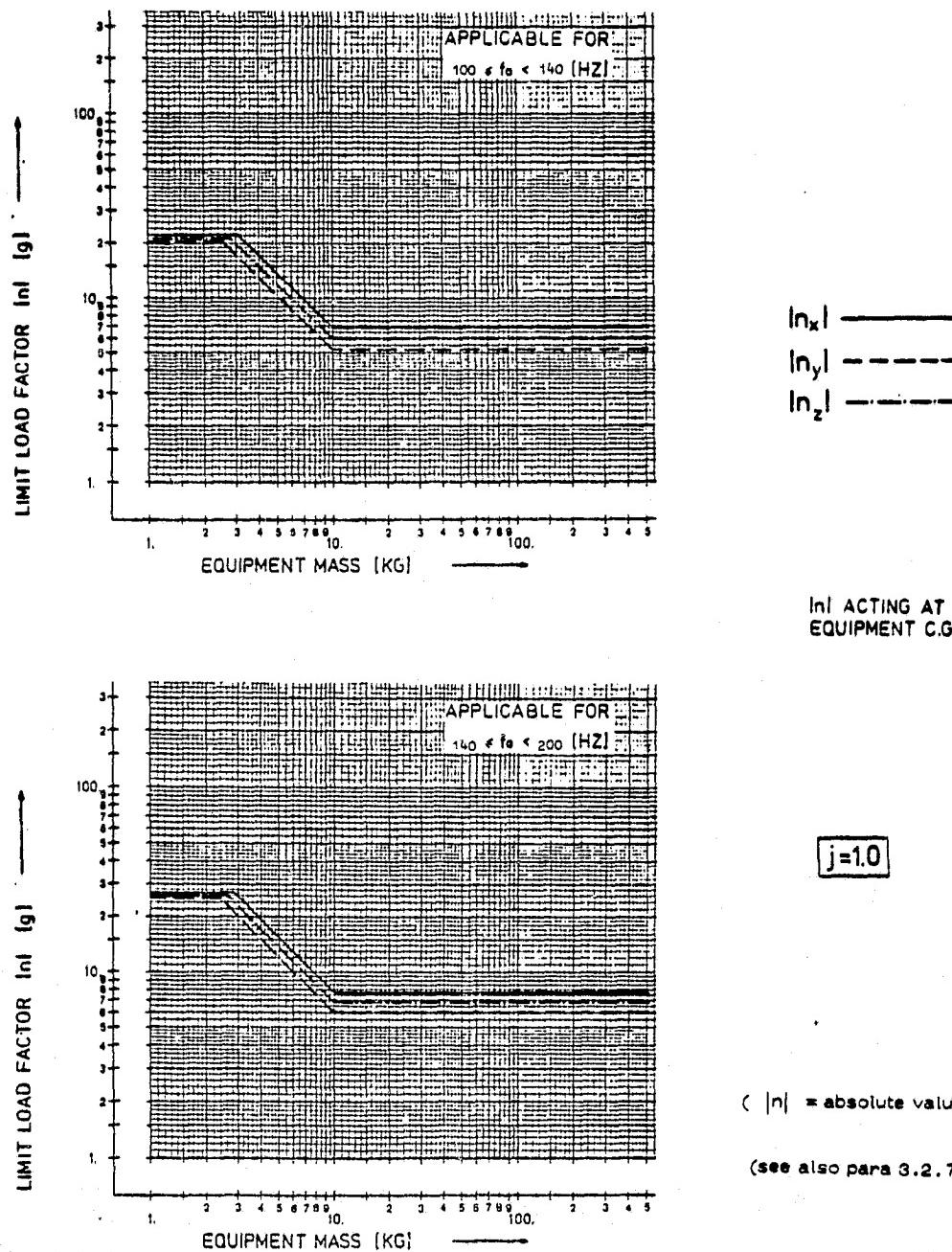
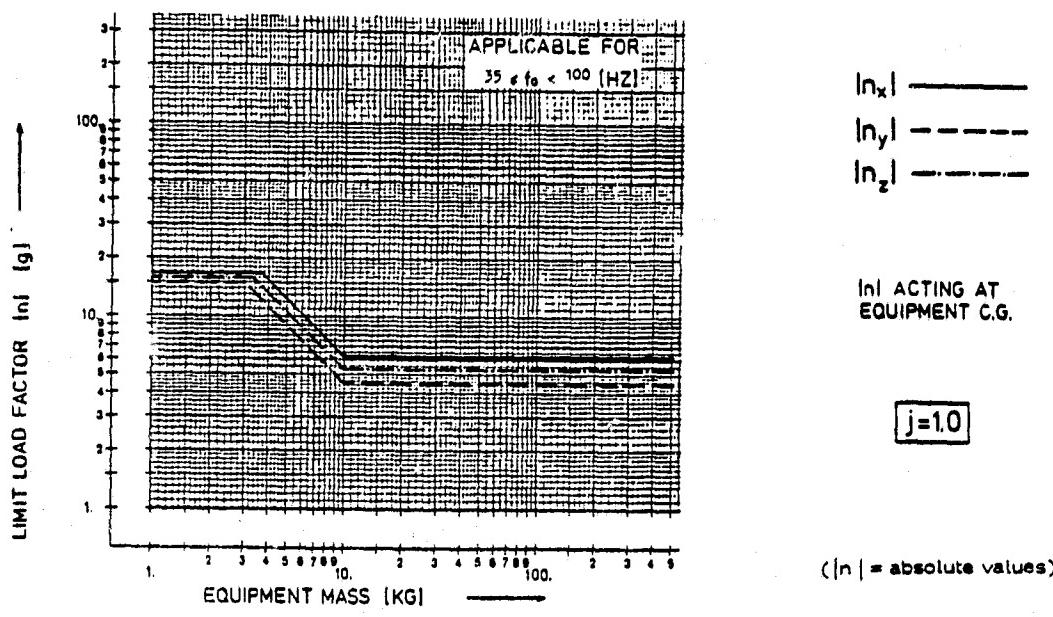


Figure 3.3 - 12a : Limit Load Factor Diagram for Dimensioning of Brackets, Zone "Floor Hardpoints"

Figure 3.3 - 12b : Limit Load Factor Diagram for Dimensioning of
Brackets, Zone "Floor Hardpoints"

3.3.1.5.2 Floor Panel Mechanical Environment

The mechanical environment for the center aisle honey comb floor panel is given in Figure 3.3 - 13a/b. This mechanical environment is applicable for the connector brackets at the center aisle cut-outs.



(see also para 3.2.7)

Figure 3.3 - 13a : Limit Load Factor Diagram for Dimensioning of
Brackets, Zone "Floor"

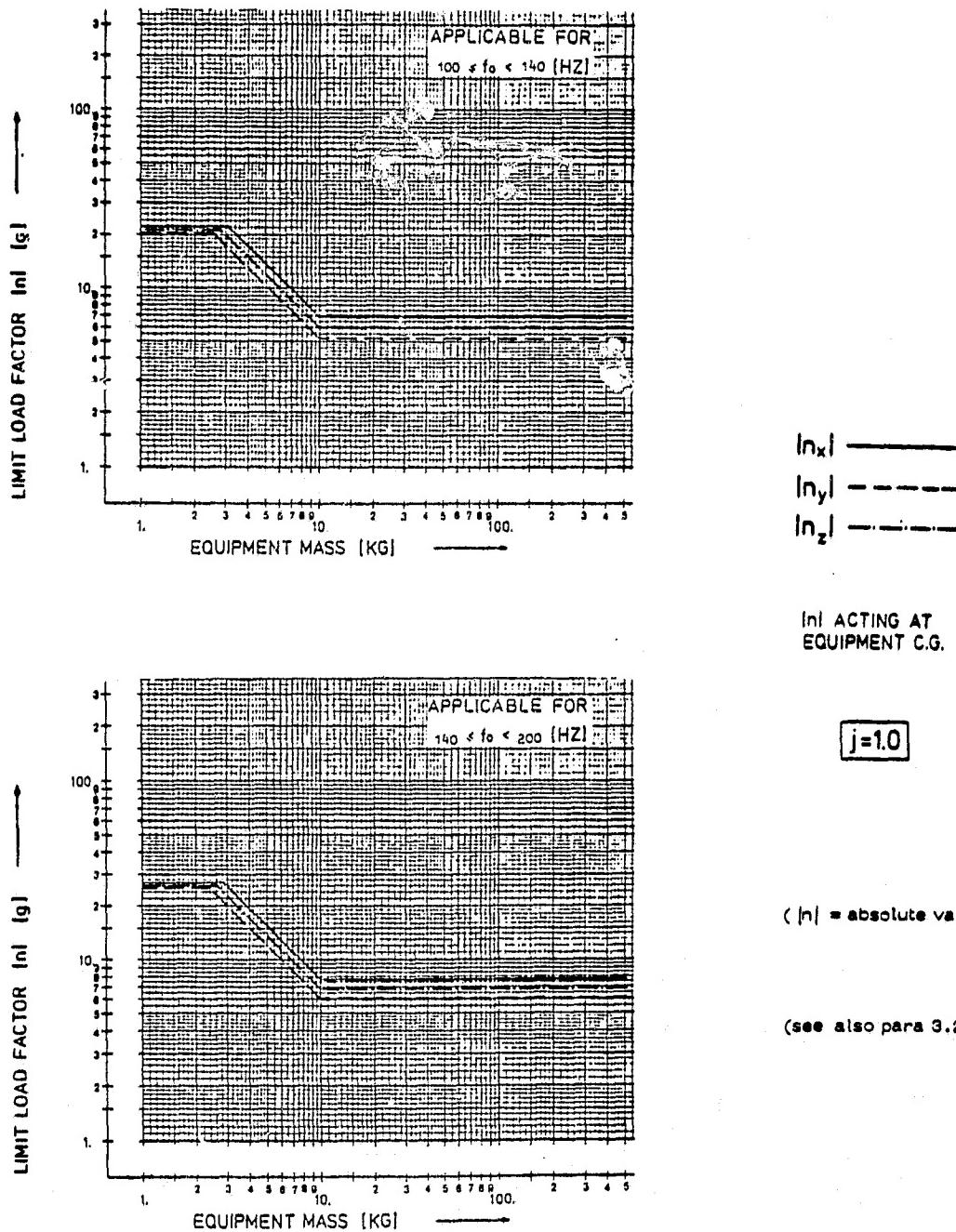


Figure 3.3 - 18b : Limit Load Factor Diagram for Dimensioning of
Brackets, Zone "Floor"

3.3.2

Side Floor

The side floor normally carries the Spacelab experiment racks. However, it is also possible to remove racks and use the respective space on the side floor directly for experiment equipment. Spacelab provides for these cases side floor panels to close out side floor where no experiment rack is installed.

The mechanical interface for experiments on the side floor is identical to the interface side floor / experiment racks, i.e. equipment can be attached to the side floor only in conjunction with the use of the overhead rack attachments (see section 3.4).

It is assumed that side floor experiment equipment will not require EPDS, CDMS, and ECS interfaces, because for these services an accommodation in experiment racks is preferable.

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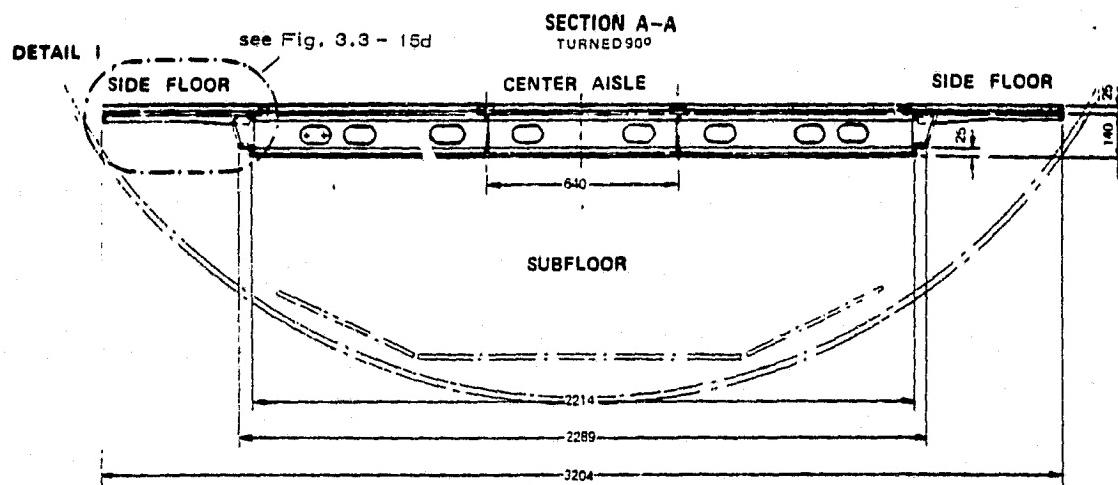
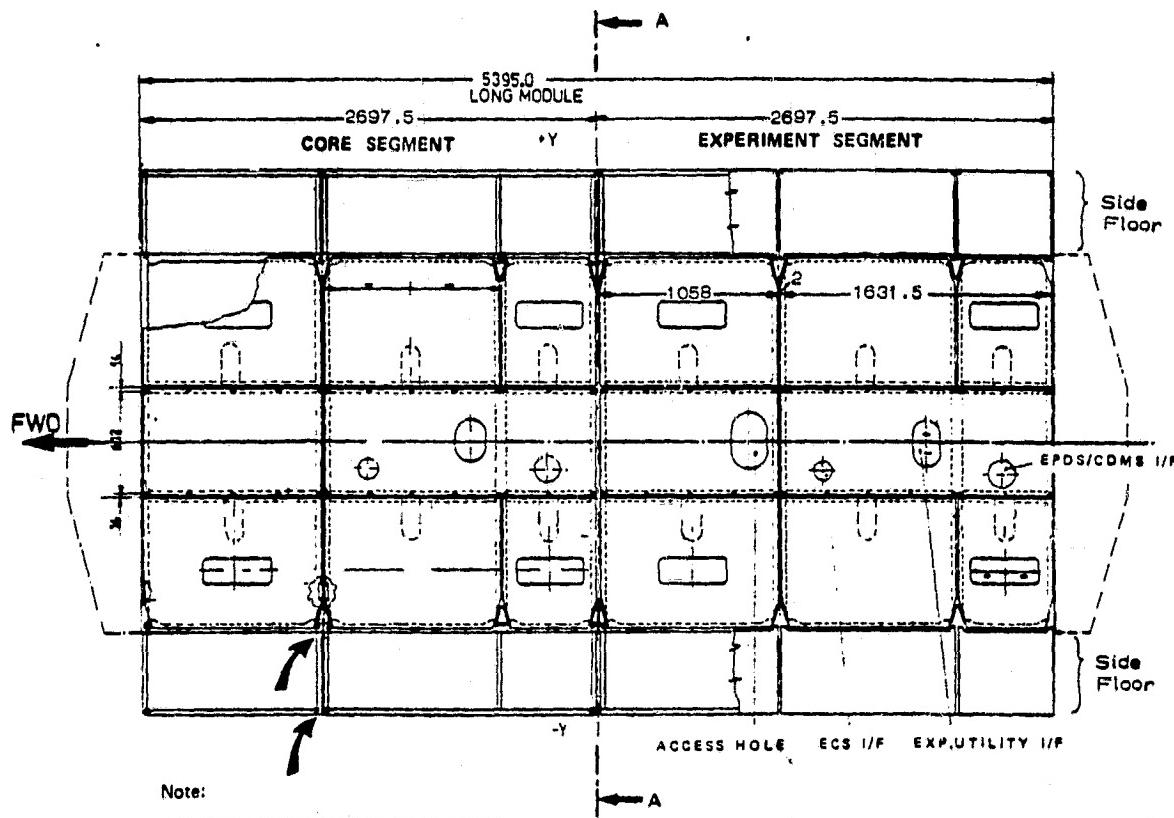


Figure 3.3 - 14 : Side Floor Overview

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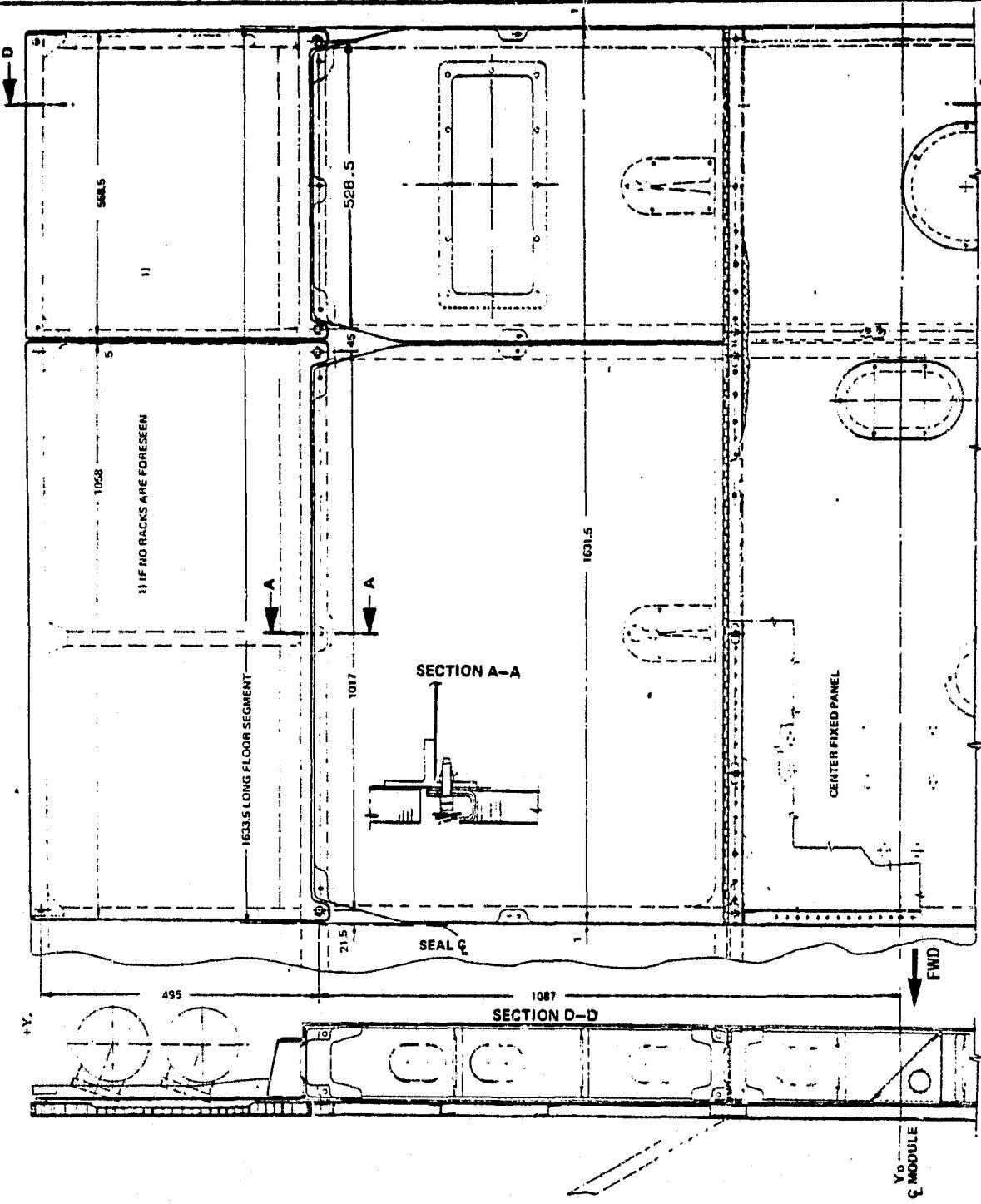
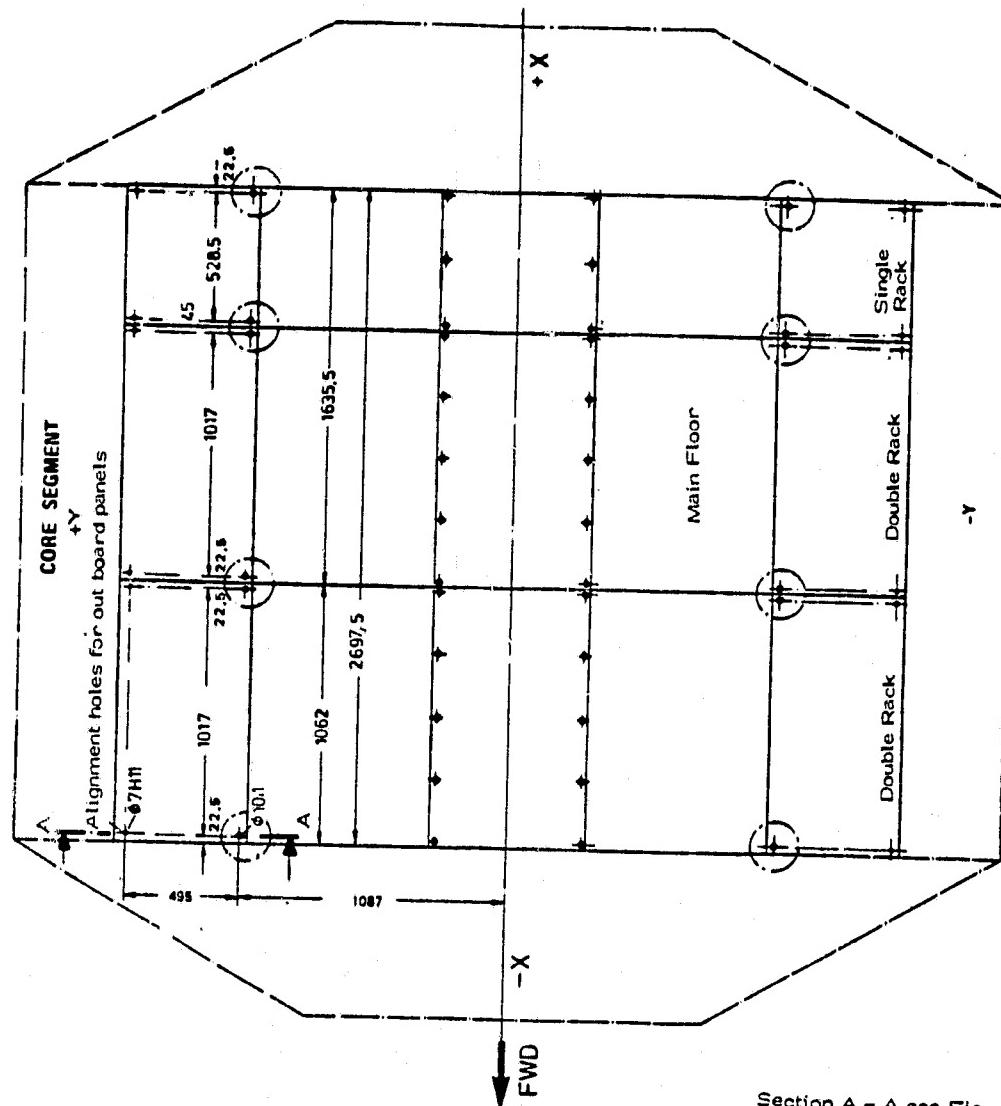


Figure 3.3 - 15a : Side Floor Dimensions and Attachment Locations

3.3.2.1 Side Floor Mechanical Interface

The location of the side floor attachment provisions, i.e. rack attachment points and alignment holes, is given in Figure 3.3 - 15 b thru 3.3 - 15 d. The rack attachment points carry loads in x, y and z. The alignment holes have no load carrying capability.



Section A - A see Fig. 3.3 - 15d

Figure 3.3 - 15 b : Side Floor Attachment - Short Module

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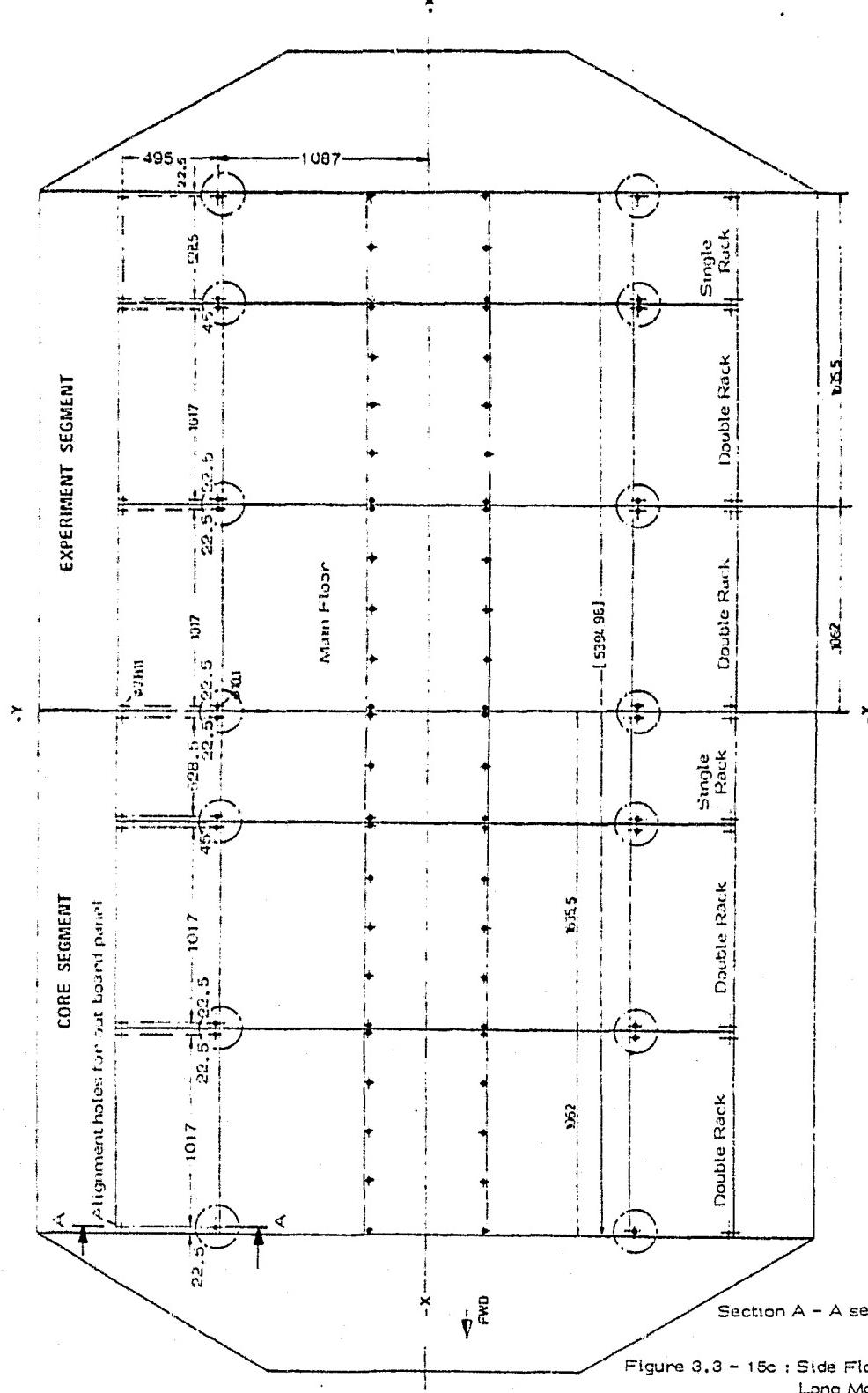


Figure 3.3 - 15c : Side Floor Attachment - Long Module

The detailed mechanical interface is given in Figure 3.3 - 15d.
The rack attachment points are basically holes through side floor panels and floor beam structure
for experiment provided M 10 bolts. The alignment holes are for guide pins defining the position,
in the x-y plane.

Section A - A (Detail 1)

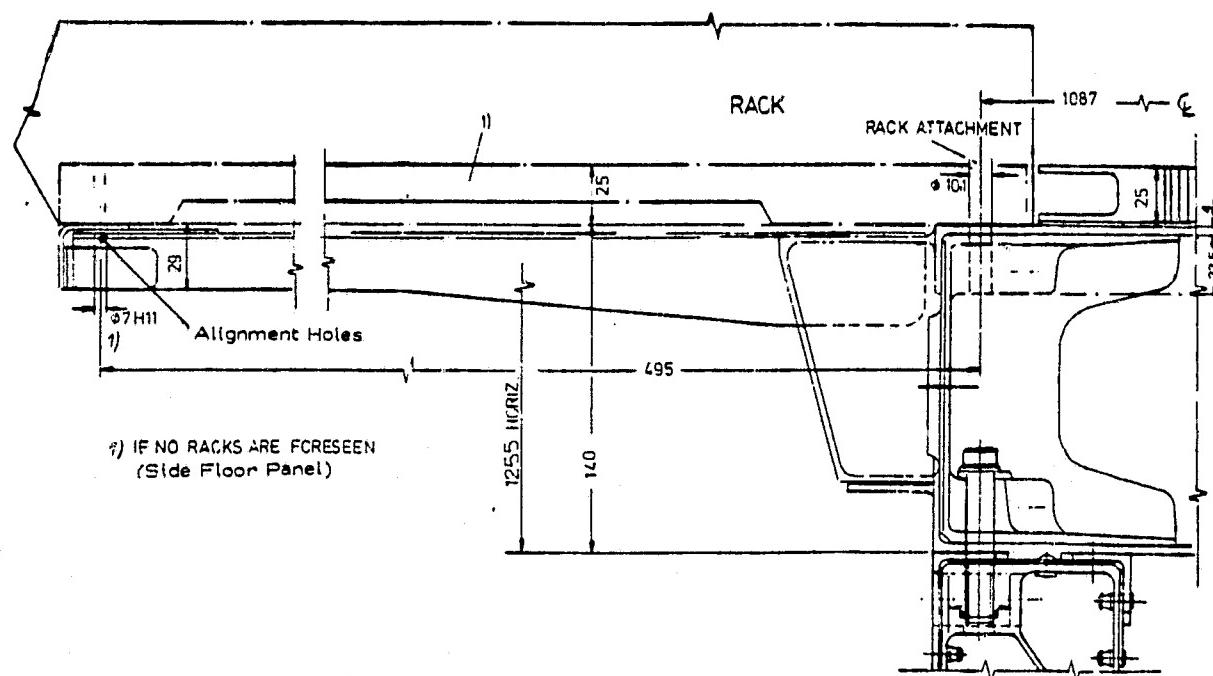


Figure 3.3 - 15d : Side Floor Attachment Provisions

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3.3.2.2

Side Floor Panels

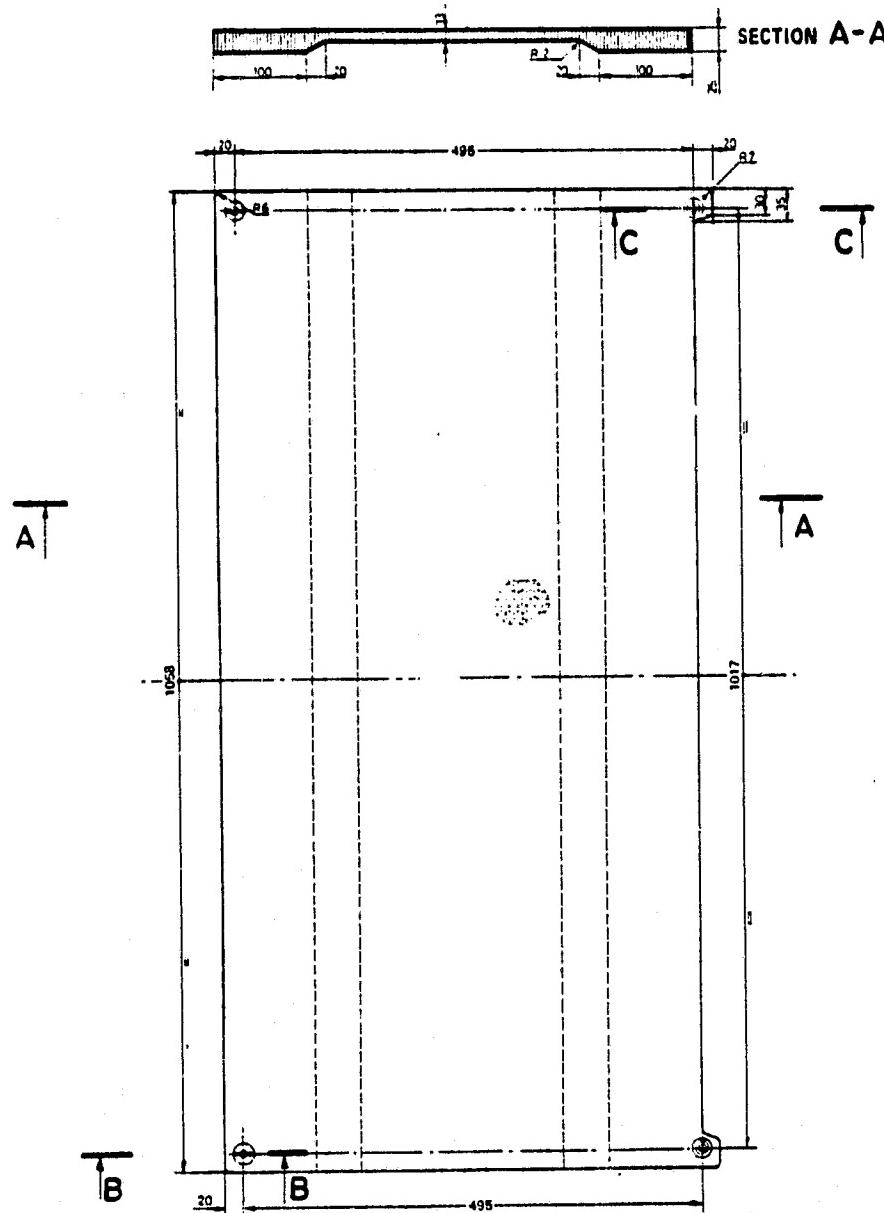
Figure 3.3 - 14 shows the location of the side floor panels on the floor.

The panels are available in two different sizes. The long side floor panels are to replace an experiment double rack, the short side floor panels are to replace a single rack. Detailed dimensions are given in Figure 3.3 - 16a and 3.3 - 16b.

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Mass m = 2.032kg

Section B-B/C-C
see Fig. 3.3-16b

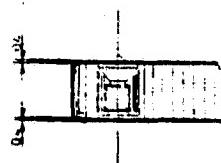
Figure 3.3 - 16a : Long Side Floor Panel

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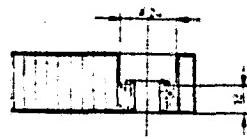
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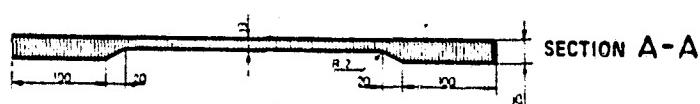
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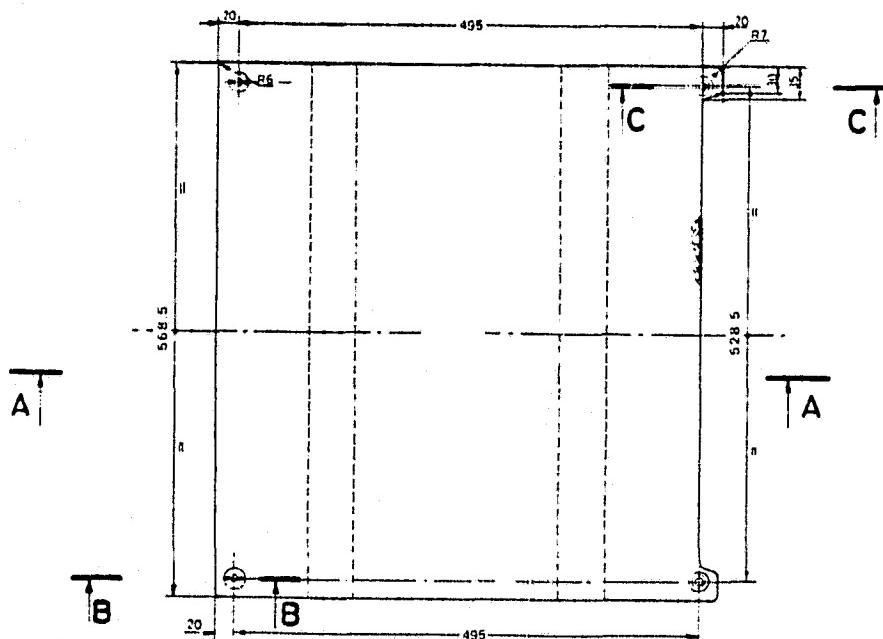
SECTION B - B



SECTION C - C



SECTION A - A



Mass m = 1.062kg

Figure 3.3 - 16b : Short Side Floor Panel

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3.3.2.3 Side Floor Load Carrying Capability

3.3.2.3.1 Overall Load Carrying Capability

The overall load carrying capability along the rack attachment points is 300 kg/m.

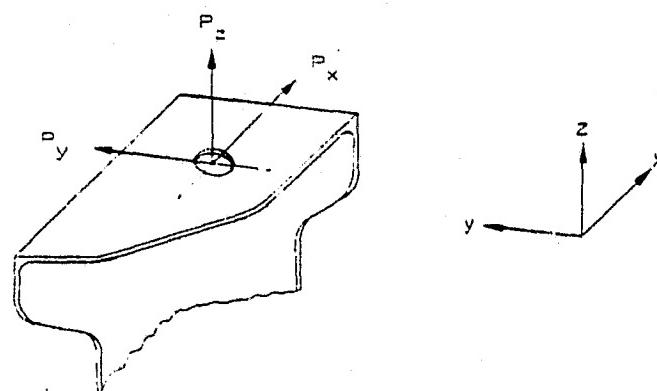
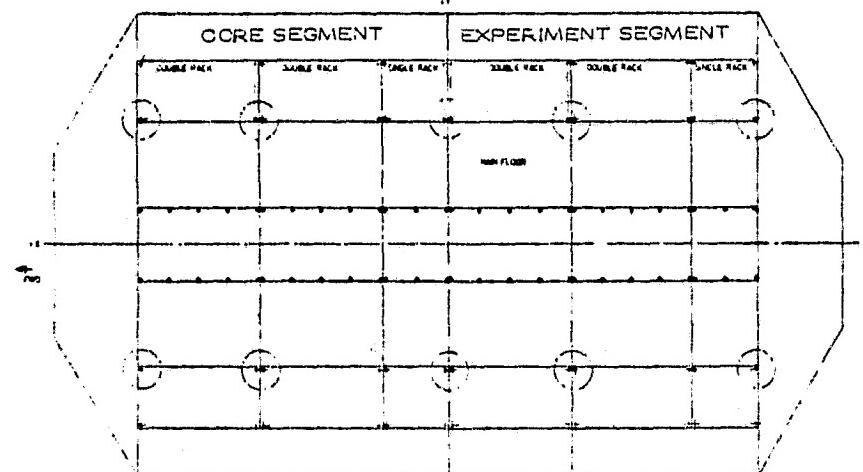
3.3.2.3.2 Local Loads

The ultimate allowable loads for a single rack attachment point are given in Figure 3.3 - 17a and 17b.
The alignment holes may be only used to facilitate experiment installation on the ground.

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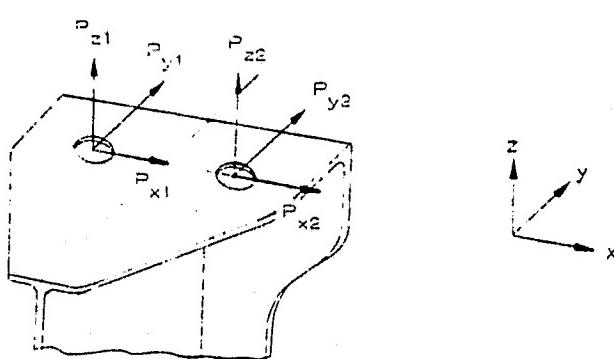
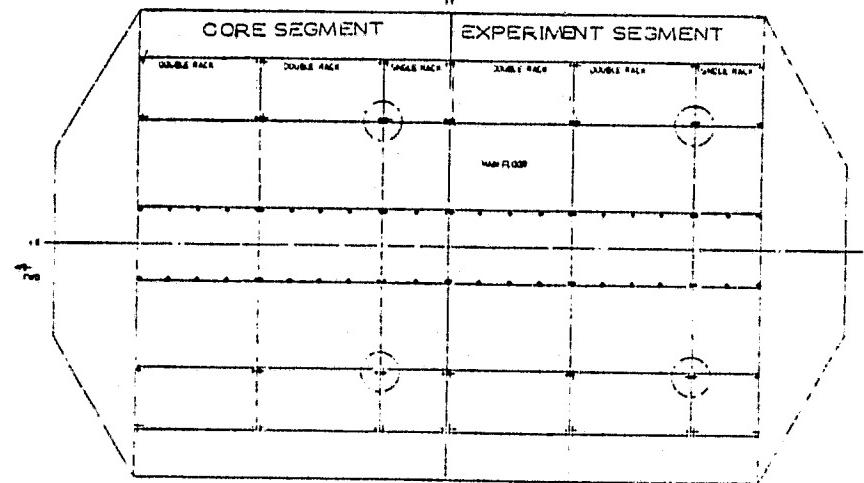


$$P_x = \pm 31969 \text{ N}$$

$$P_y = \pm 10395 \text{ N}$$

$$P_z = \pm 24124 \text{ N}$$

Figure 3.3 - 17a : Max. Combined Local Interface Loads of Floor to Rack Attachments



$$P_{x1,2} = 0 \text{ N}$$

$$P_{y1} = -P_{y2} = 6374 \text{ N}$$

$$P_{z1} = 18808 \text{ N}$$

$$P_{z2} = 3512 \text{ N}$$

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Figure 3.8 - 17b : Max. Combined Local Interface Loads of Floor to Rack Attachments

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3.3.2.4 Mechanical Environment

The mechanical environment on the side floor is identical to the environment defined in 3.3.1.5.

3.3.3 Underfloor Area

The volume under the mainfloor in the experiment segment of the long module provides ample space for the accommodation of payloads. The underfloor mainly will serve for stowage purpose. Therefore only mechanical interfaces will be called out in this section.

3.3.3.1 Underfloor Area Usable Envelope

The envelope of the usable volume is given in Figure 3.3 - 18.

Substantial penetrations into this envelope stem from

- Spacelab subsystems, i.e. EPDB's and subsystem RAI together with access volumes required for maintainability of these subsystems
- Fire suppression assembly, i.e. fire suppression lines and fire suppression bottles together with access volume
- Experiment utility routing envelopes as defined in section 3.9 of this appendix.
- Clearances to allow proper air flow of cabin loop return air through debris traps (see Figure 3.3 - 20) and center aisle ECS cut-out. The required clearances have to be evaluated for the actual underfloor experiment accommodation.

On orbit the access to the underfloor is through the hinged floor panels (see Figure 3.3 - 19).

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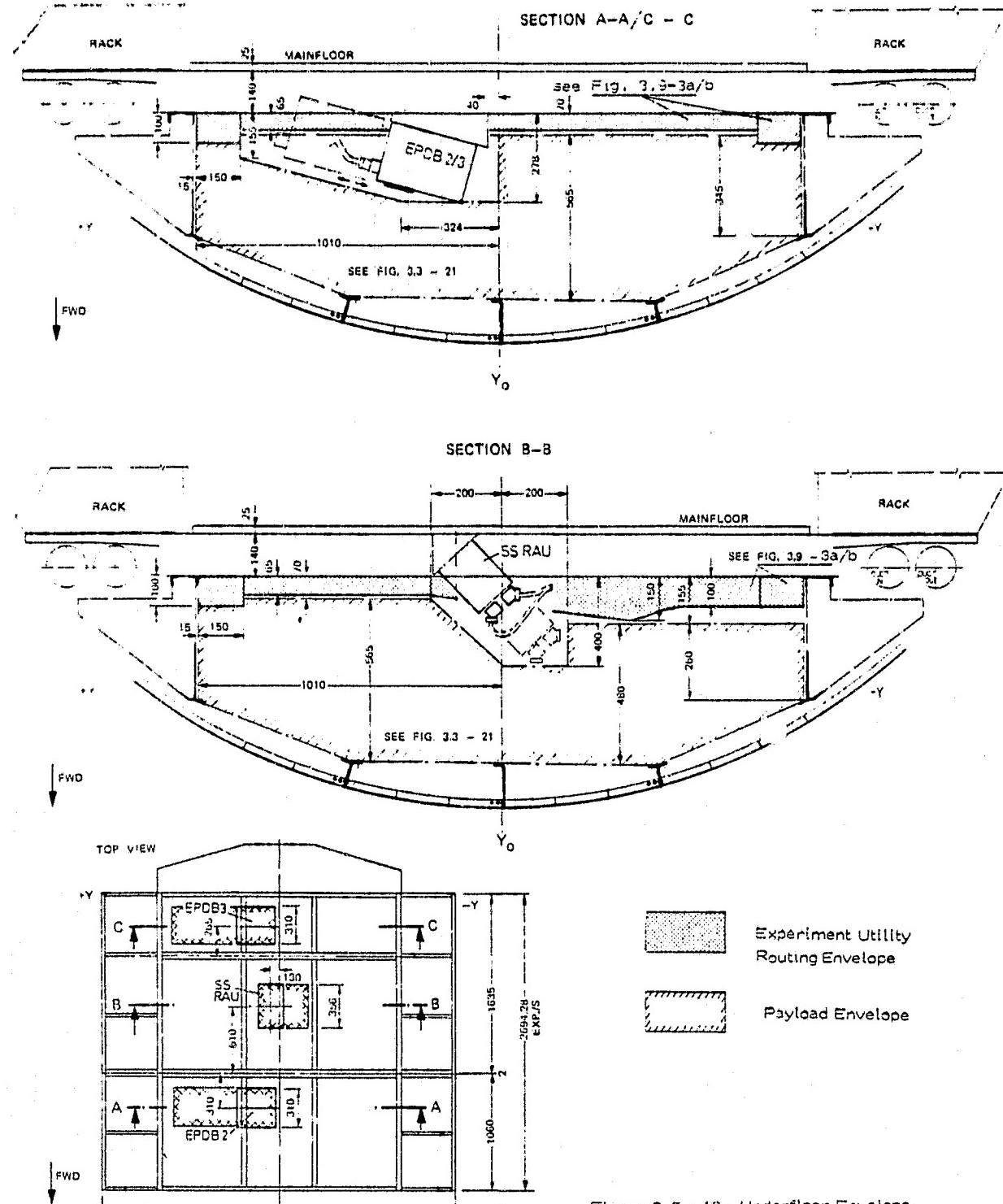


Figure 3.3 - 18 : Underfloor Envelope

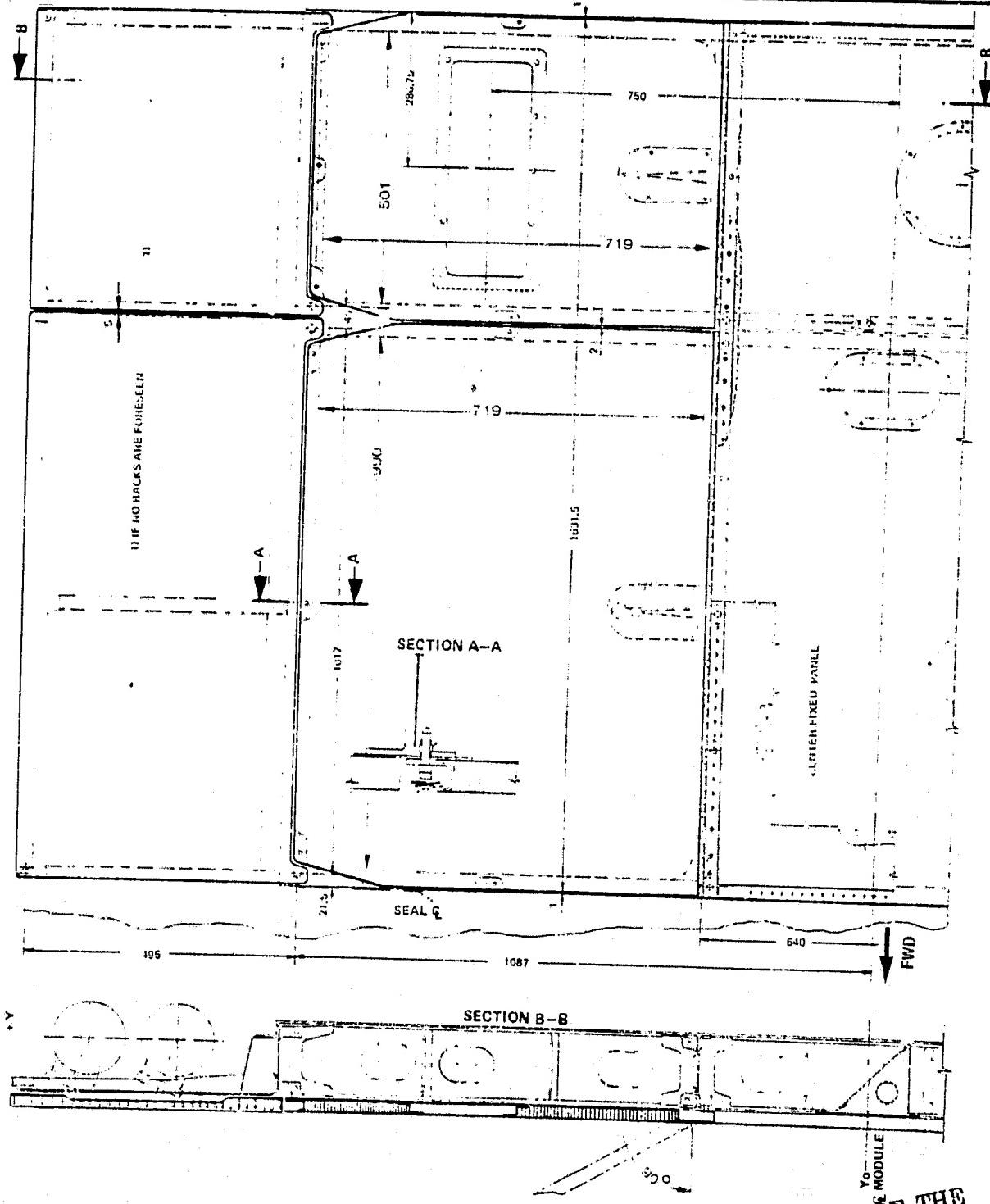


Figure B.3 - 19 : Hinged Floor Panels

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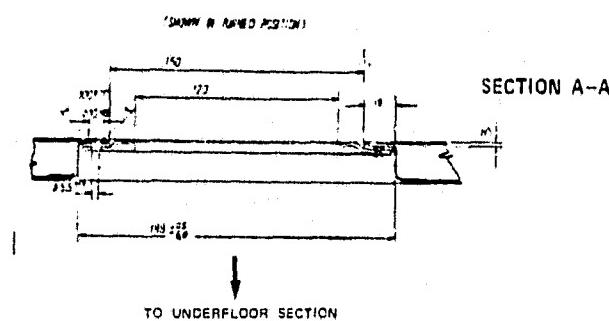
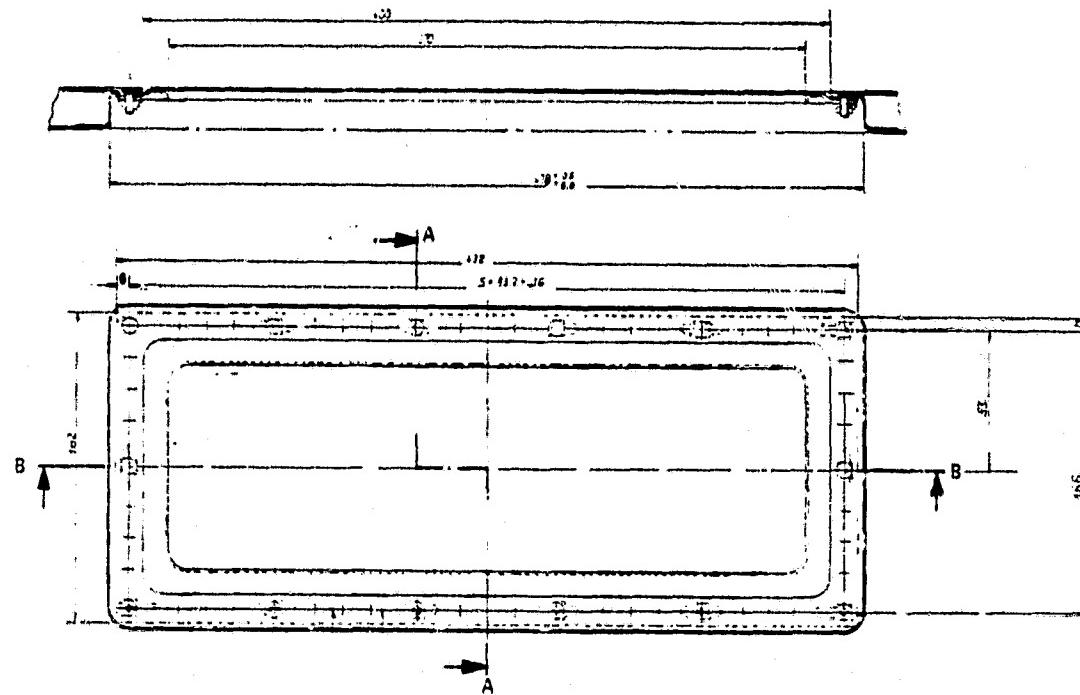


Figure 3.3 - 20 : Debris Trap

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3.3.3.2 Underfloor Mechanical Interface

The location of the underfloor attachment provisions, consisting of four longerons with attachment holes, is given in Figure 3.3 - 2*.

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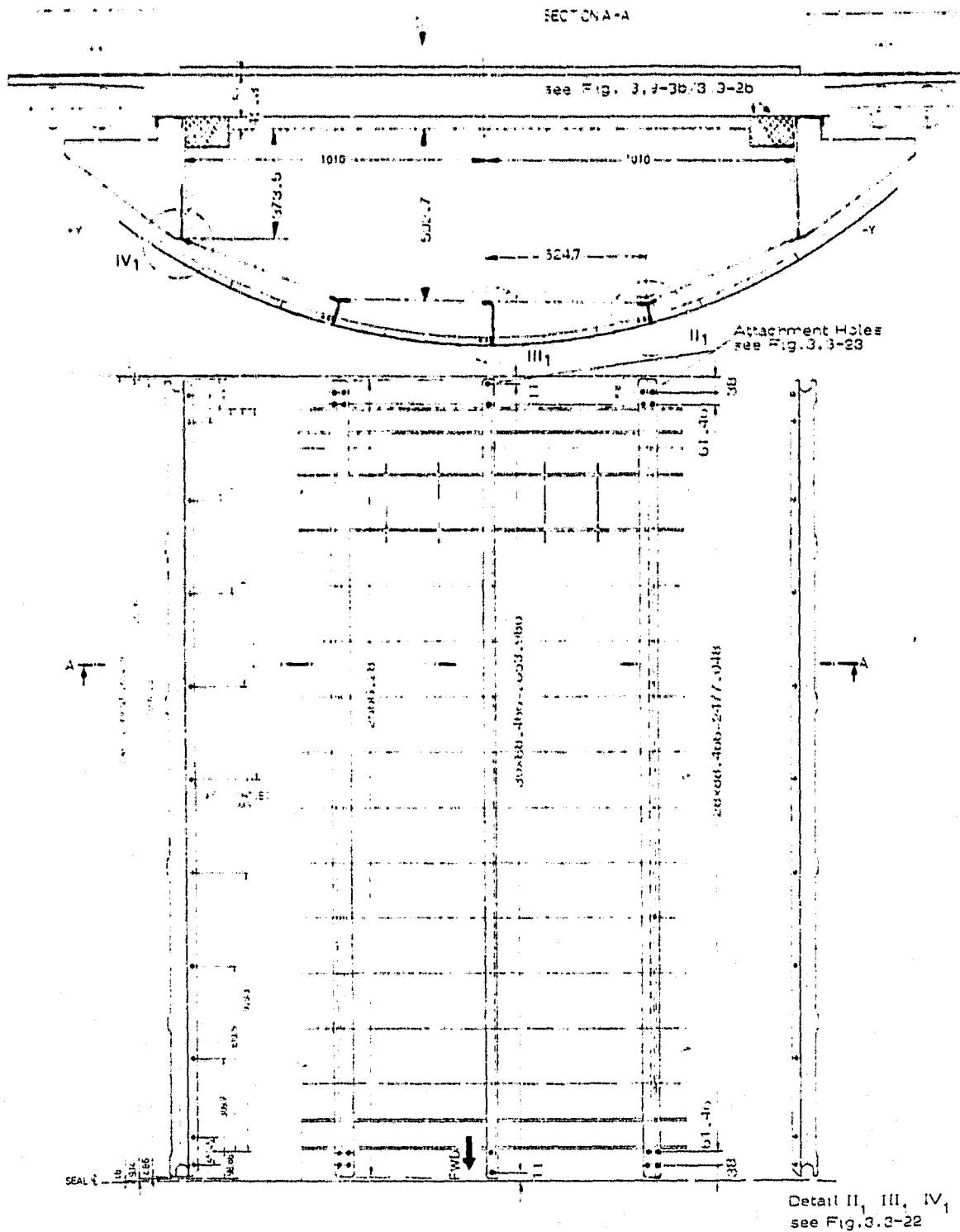


Figure 3.3 - 21 : Experiment Segment Underfloor Area - Structure and Dimensions

The detailed mechanical interface is given in Figure 3.3 - 22. The underfloor attachment points are basically holes in the longerons for user provided M 6 bolts.

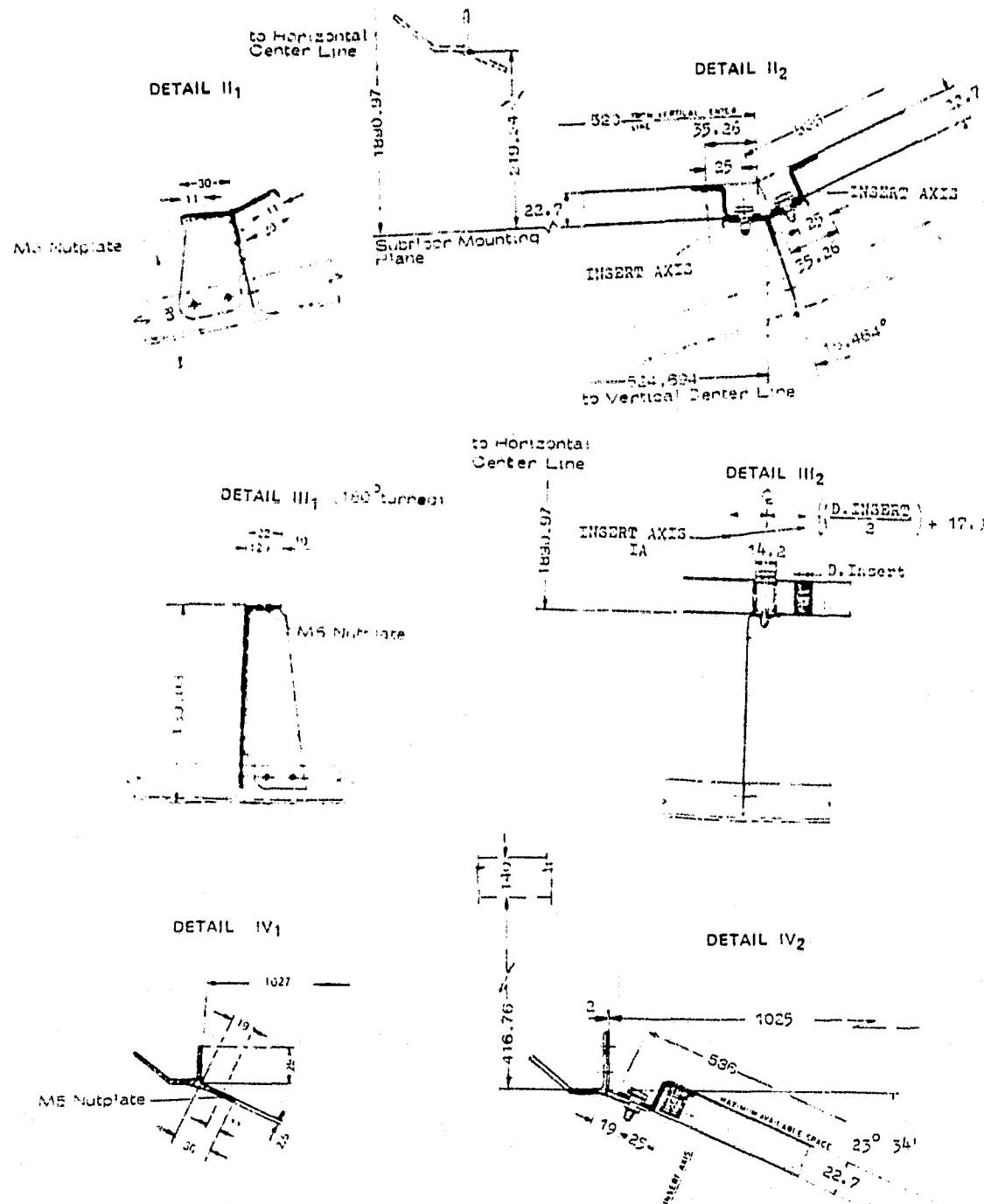


Figure 3.3 - 22 : Mechanical Underfloor Interface - Details

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3.3.3.3

Example of Equipment Mounting in Underfloor

Equipment in the underfloor area can be accommodated on a user provided subfloor similar to the subsystem mounting in the core segment. Such a subfloor is mandatory to protect the module shell.

Since present long module analysis does not include any experiment masses accommodated in the underfloor area of the experiment segment, additional detail analysis will be required for such load cases.

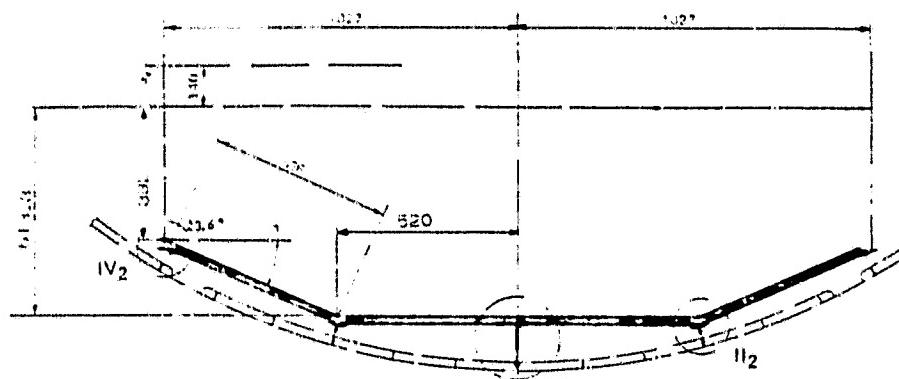
As an example the subsystem subfloor of the core segment is given in Figure 3.3 - 23.

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Details see Figure 3.3 - 22

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(*) INDICATES MODE INTERFACE INFORMATION

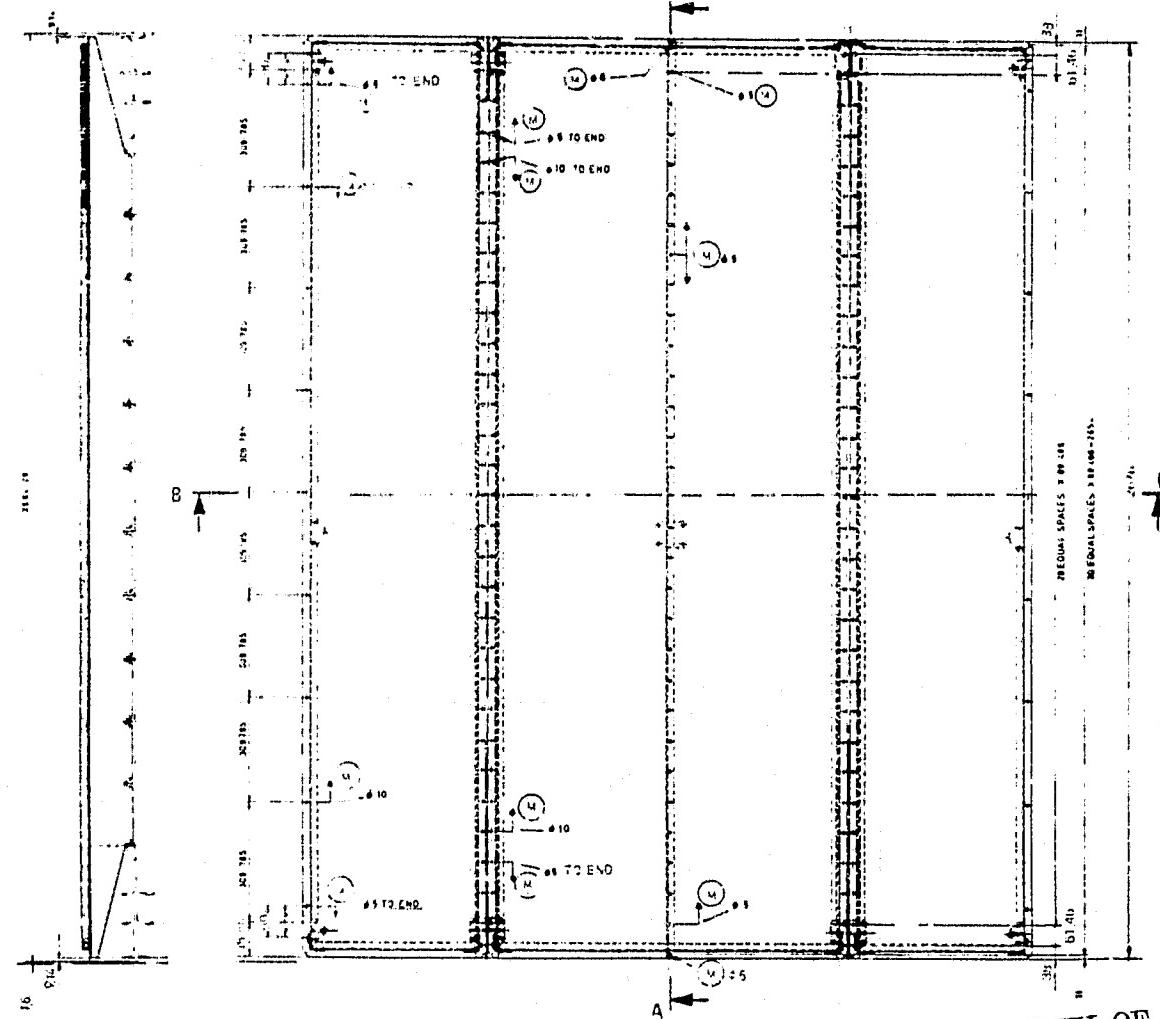


Figure 3.3 - 22 : Honeycomb Subfloor Structure (Not Spacelab supplied)

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The load carrying capability of this subfloor is 300 kg/m. Local Load carrying data of the underfloor attachment points are not available.

The mechanical environment on this subfloor is given in Figure 3.3 - 24a and 24b.

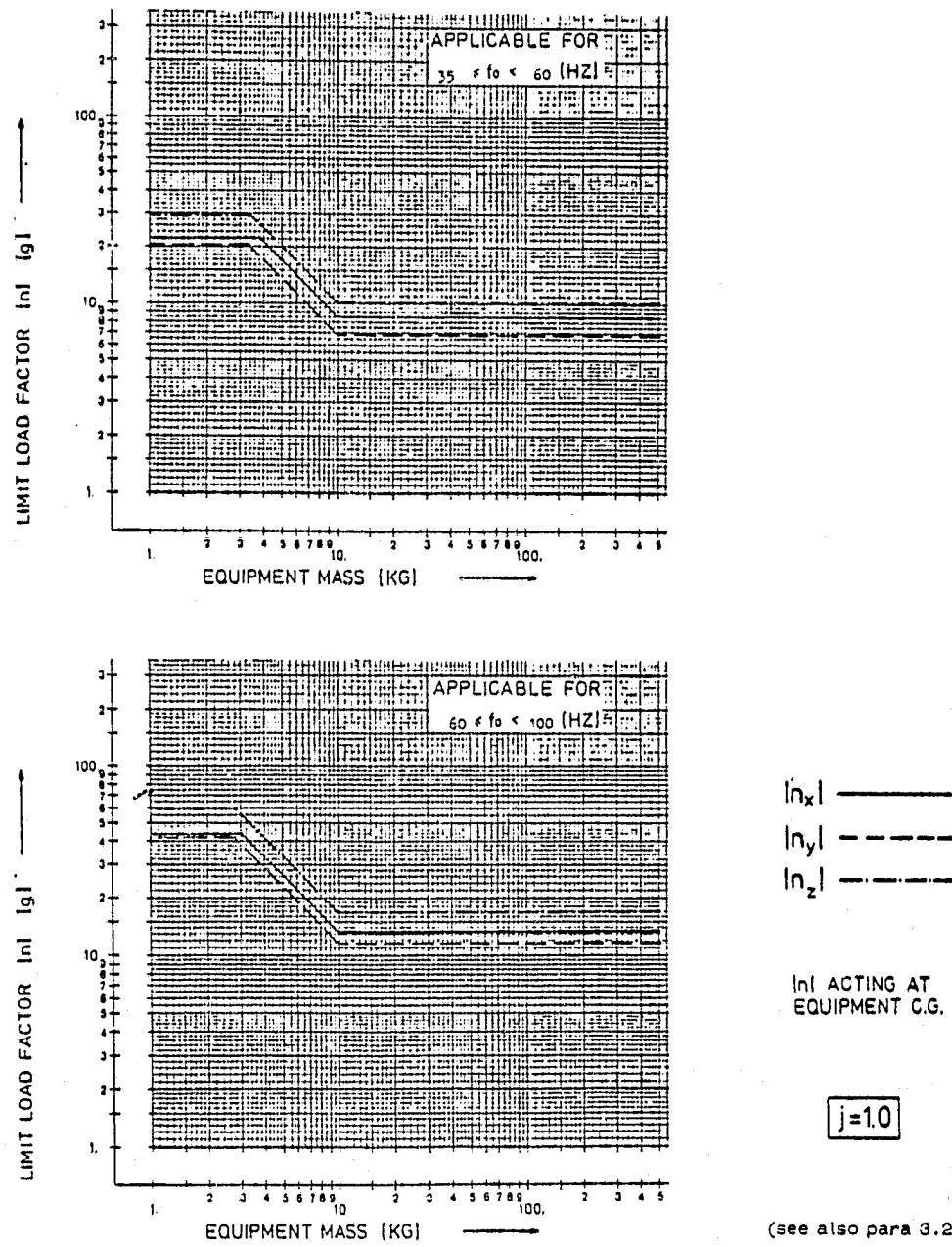
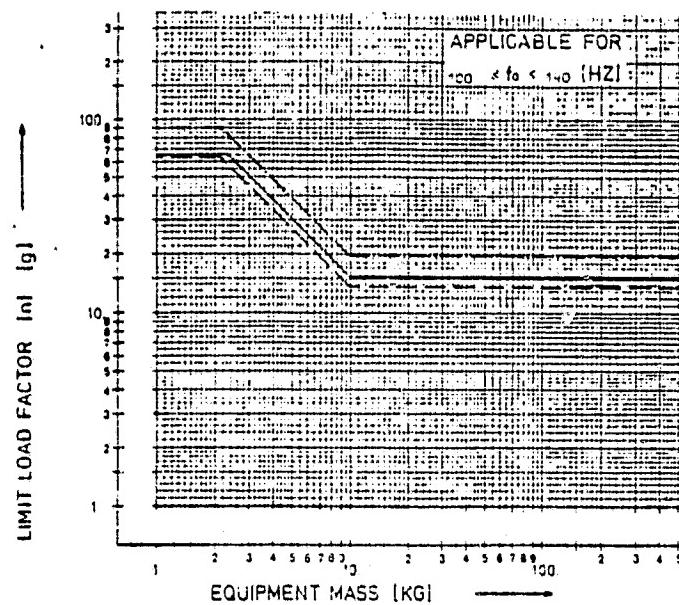
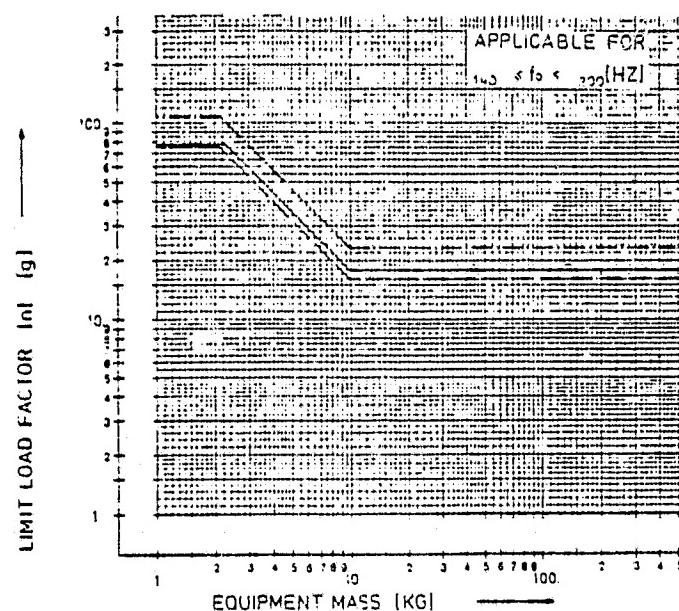


Figure 3.3 - 24a : Limit Load Factor Diagrams for Dimensioning of Brackets,
Zone "Floor Honeycomb Subfloor"



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 $|n_y|$ - - -
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$|n|$ ACTING AT
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j=1.0

($|n|$ = absolute values)

(see also para 3.2.7)

Figure 3.3 - 24b : Limit Load Factor Diagram for Dimensioning of Brackets,
Zone "Floor Honeycomb Subfloor"

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3.4

Overhead Structure

The overhead structure normally supports overhead stowage containers and experiment racks. However, in locations where no overhead stowage containers or racks are installed, the respective interfaces are available for experiments.

EPDS services for experiments in the overhead area are provided through the CPSE connector brackets (see sec. 3.8.3).

CDMS services are only through user provided cabling from experiment racks.

ECS services are provided by the cabin loop. However, the volume above the overhead stowage container attachment has to be considered as a stagnation area.

Liquid cooling requires user provided plumbing to the experiment heat exchanger in rack 4. A possible liquid line routing to the overhead structure is described in section 3.9.3.

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3.4.1 Rack Attachment

3.4.1.1 Rack Attachment Interface

Where no rack is installed the attachment fittings for the rack struts at the overhead structure may be regarded as an interface for experiment equipment. This interface can be used only in conjunction with the rack interface at the side floor (see section 3.3.2).

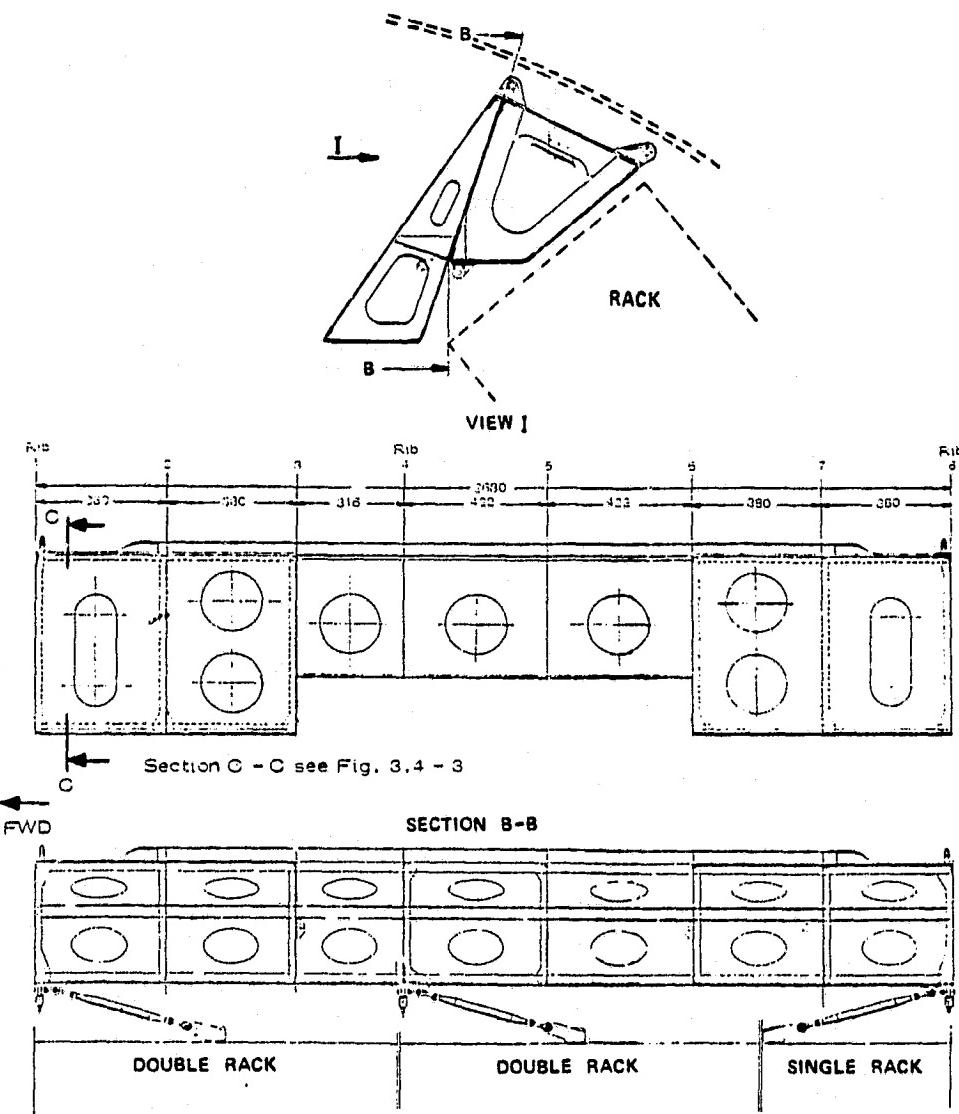
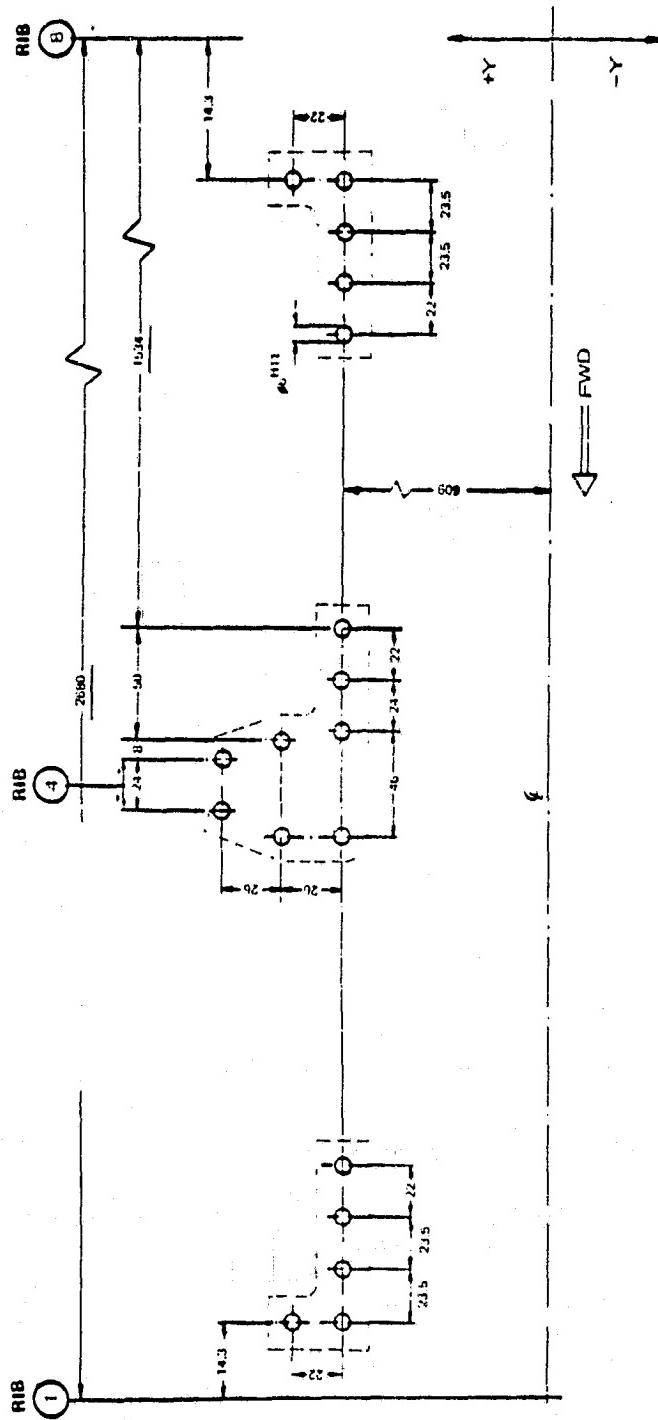


Figure 3.4 - 1 Overhead Structure - Right Side (Short Module)



Note : Rack struts mounting pattern mirrored about

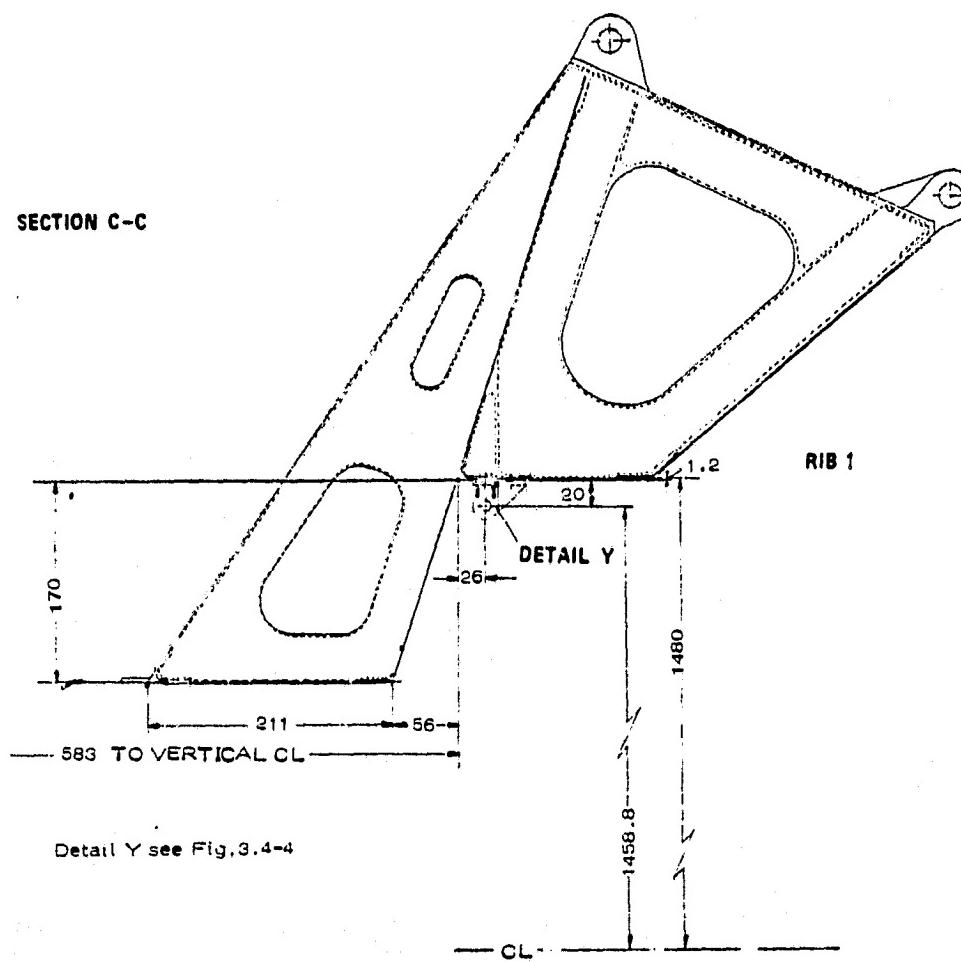
The experimenter should use the attachment fittings shown in Figure 3.4 – 4, which will be mounted to this hole pattern.

Figure 3.4 – 2 : Hole Pattern for Rack Attachment Struts (Short Module)

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Detail Y see Fig.3.4-4

Figure 3.4 - 3 : Overhead Structure - Rib 1

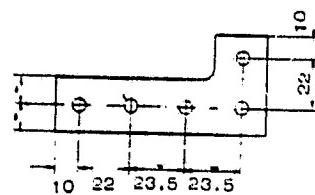
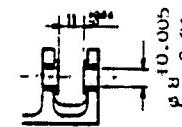
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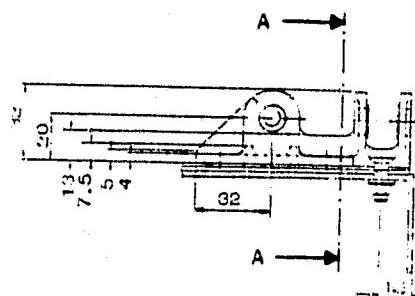
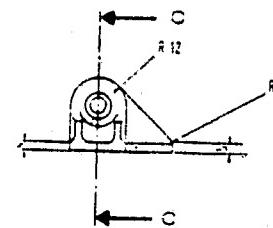
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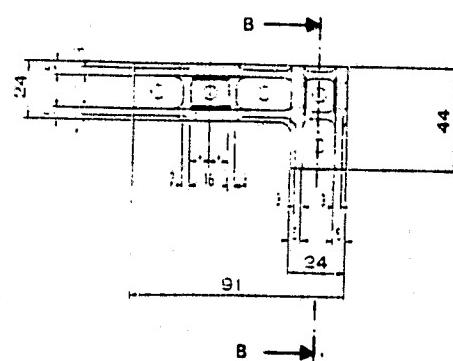
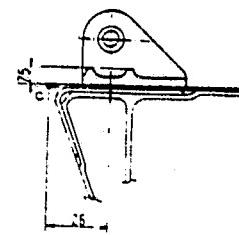
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SECTION A-A



SECTION B-B



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DETAIL Y

Figure 3.4 - 4 : Rack Attachment Fittings - Rib 8 (mirrored for Rib 1)

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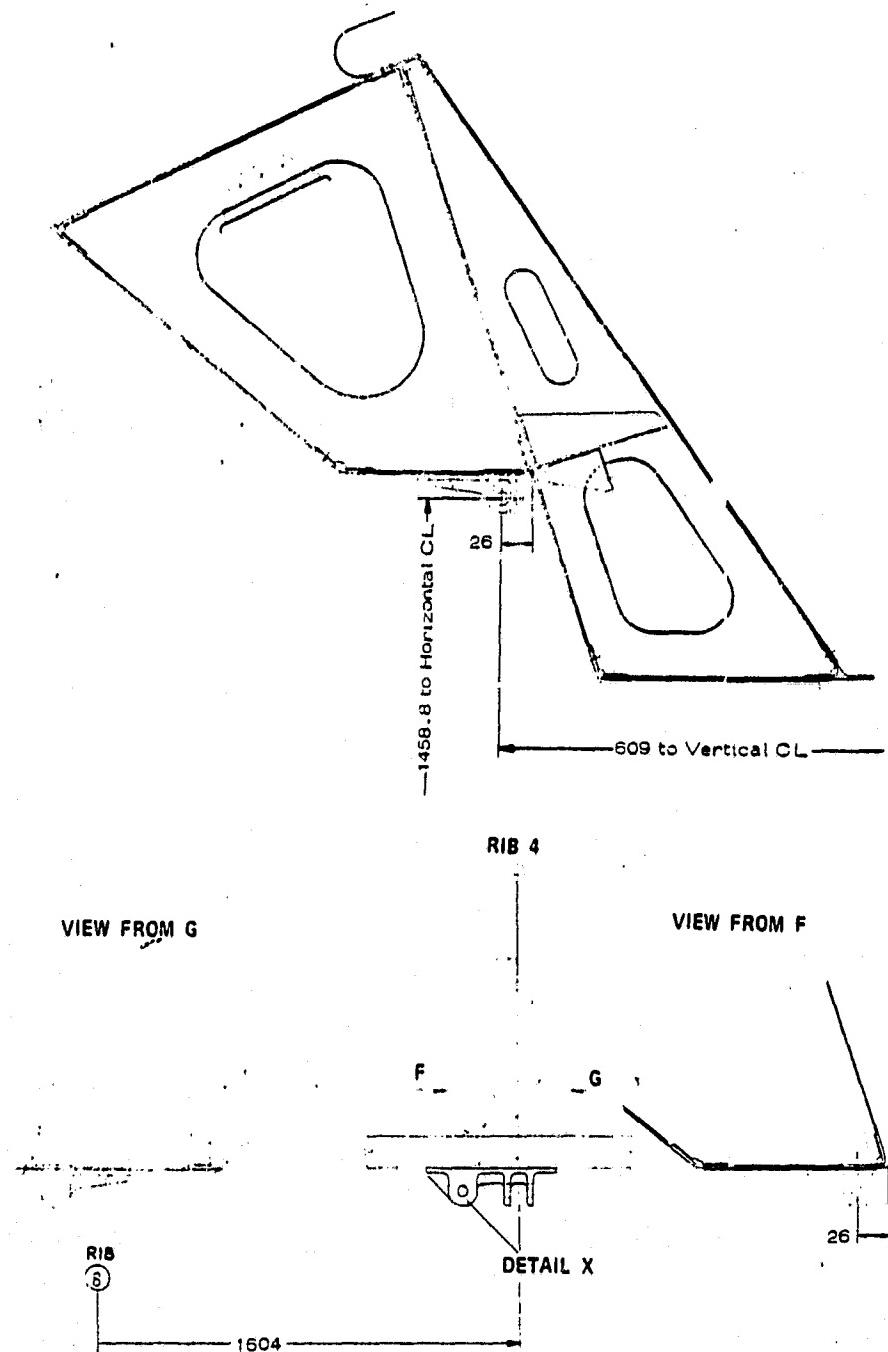


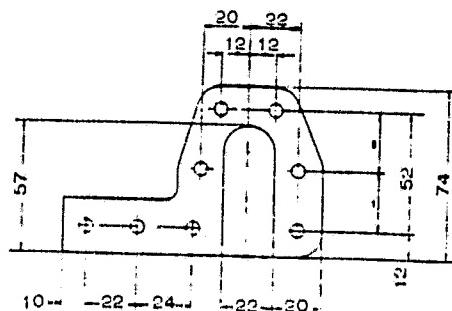
Figure 3.4 - 5 : Overhead Structure - R ib 4

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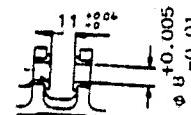
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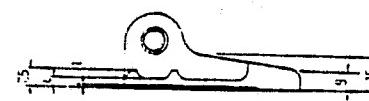
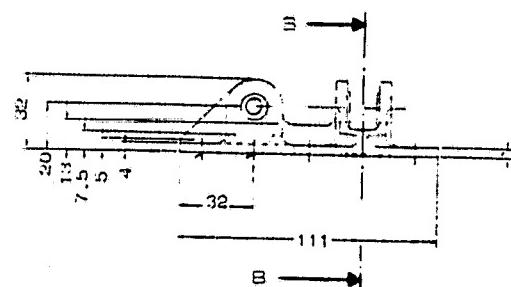
DETAIL X



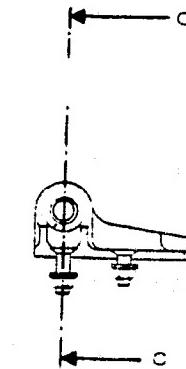
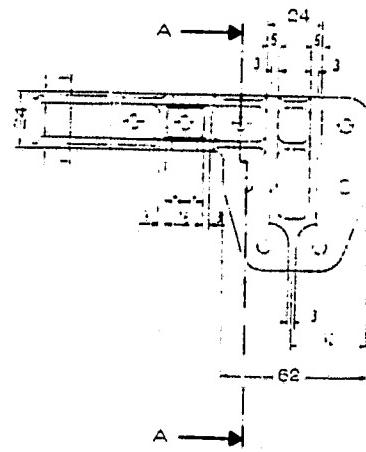
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SECTION B-B



SECTION A-A



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DETAIL X

Figure 3.4 - 6 : Rack Attachment Fitting - Rib 4

3.4.1.2

Rack Attachment Loads

The local ultimate allowable loads are given in Figure 3.4-7a and b.
The overall load carrying capability is TBD.

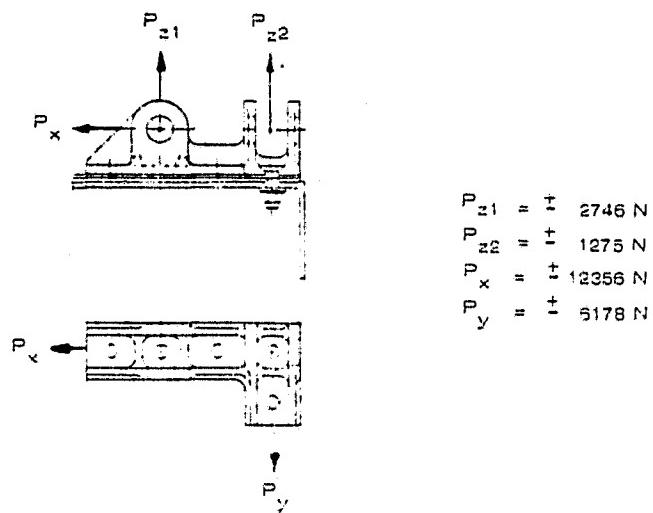


Figure 3.4-7a Max. Combined Local Interface Loads - Rack Attachment Fittings (Rib 1 + 8)

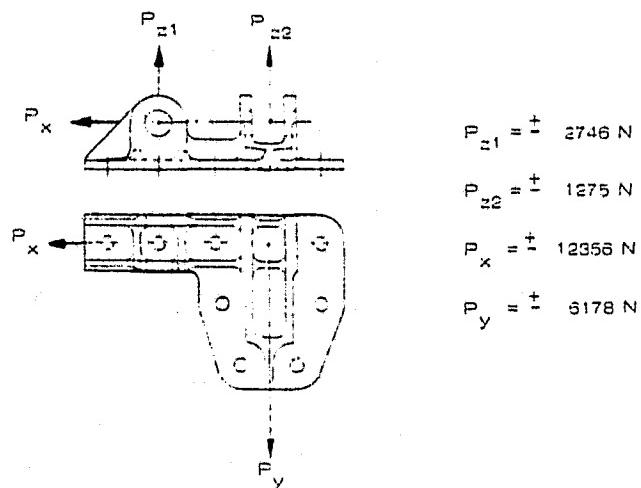
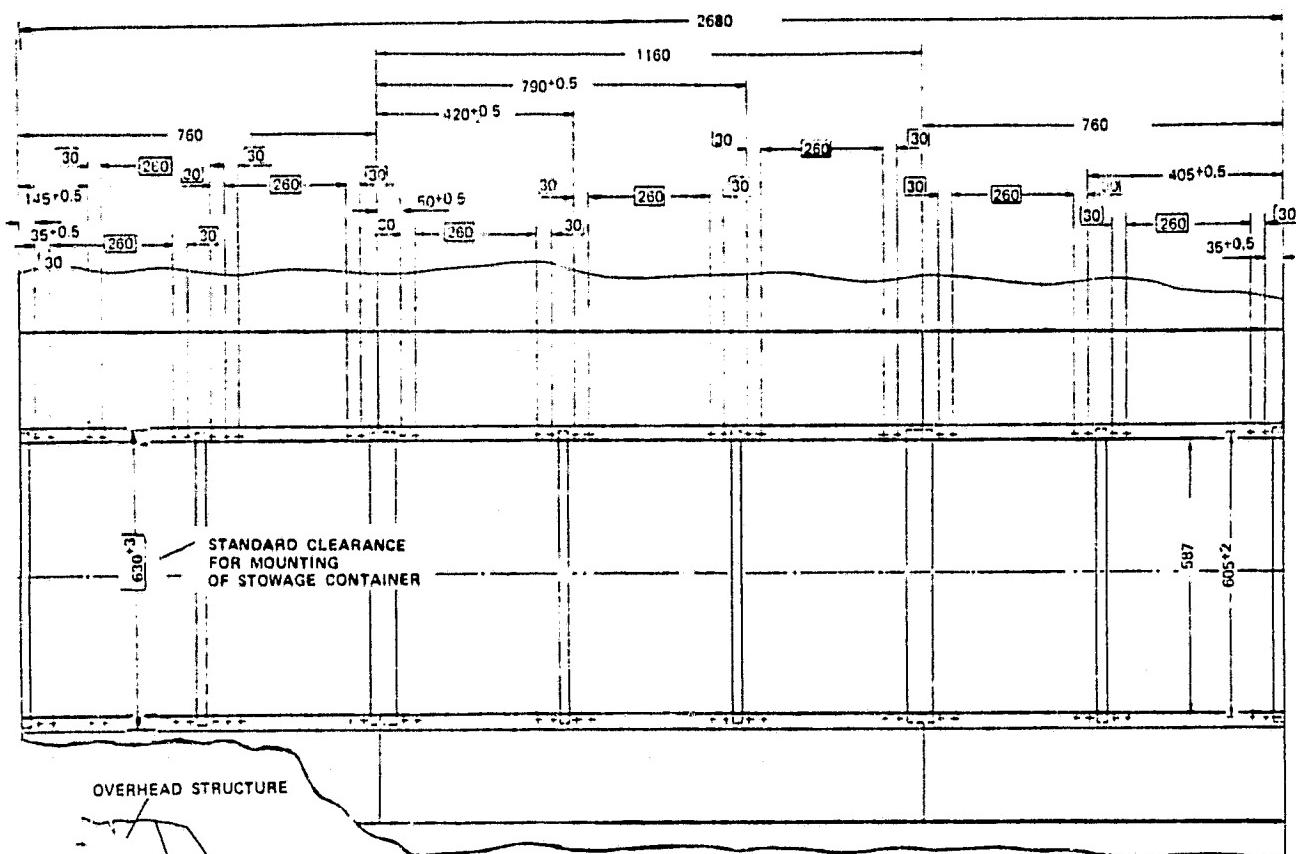


Figure 3.4-7b Max. Combined Local Interface Loads - Rack Attachment Fittings (Rib 4)

3.4.2 Overhead Stowage Container Attachment

3.4.2.1 Overhead Stowage Container Attachment Interface

Where no overhead stowage container is installed the respective attachment holes are available for experiments. Experiment equipment will be attached to these holes, which are equipped with nuts, by experimenter provided M 5 bolts.



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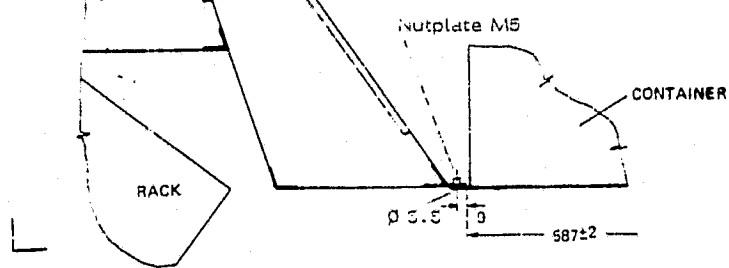


Figure 3.4 - 8 :
Hole Pattern of Overhead Container
and Equipment Attachment

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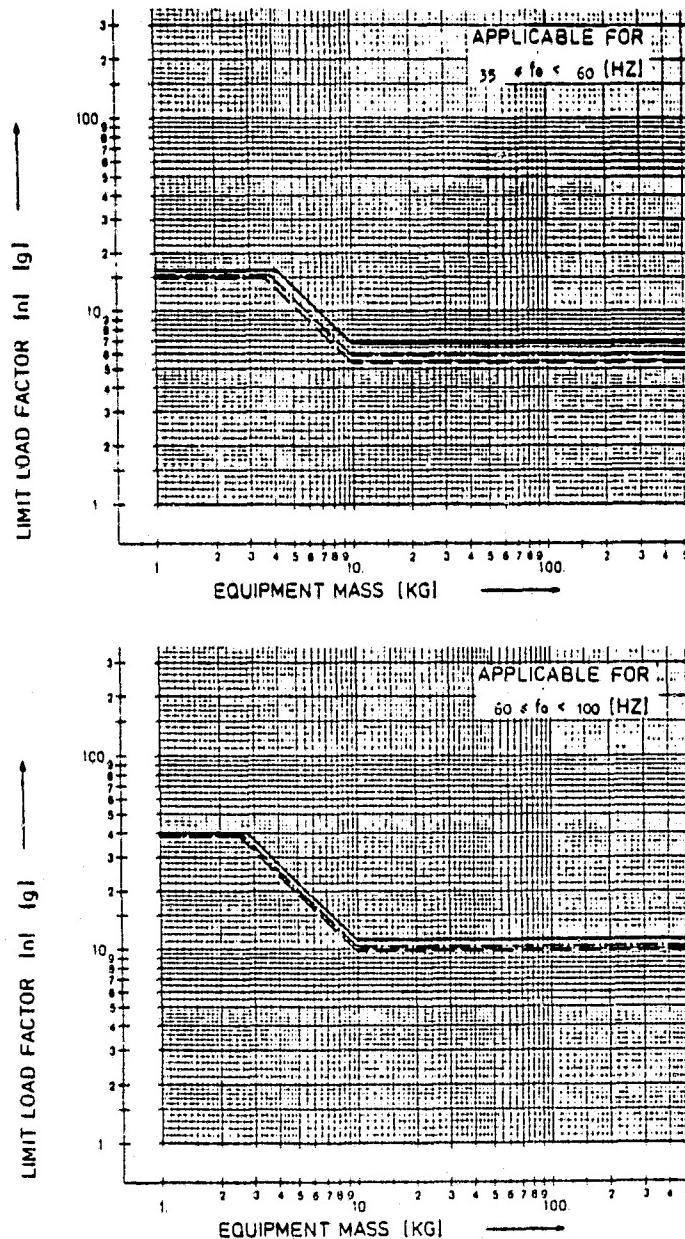
3.4.2.2

Overhead Stowage Container Attachment Loads

'Will be supplied in a later issue!

3.4.3 Overhead Structure Mechanical Environment

The diagrams of the mechanical environment for the overhead structure, which is applicable for rack attachment as well as for overhead stowage container attachment, are given in Figure 3.4 - 9. For application of the diagrams see para 3.2 - 7 of this appendix.



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$j=1.0$

($|n|$ = absolute values)

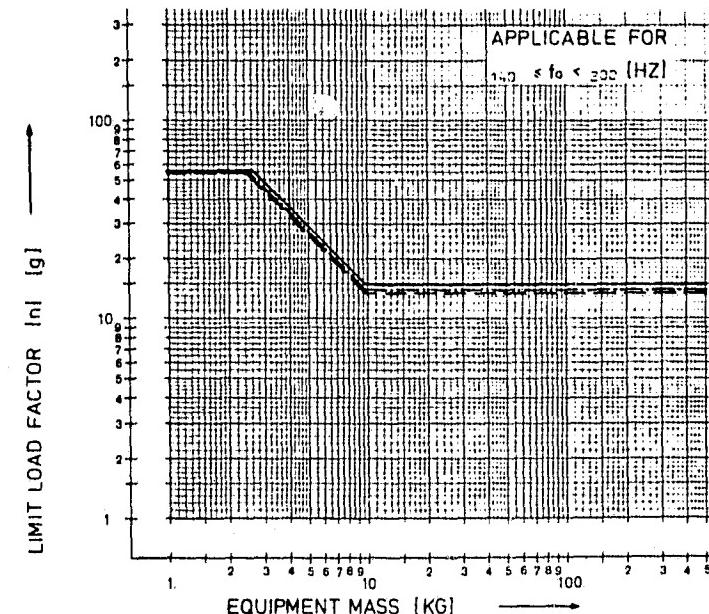
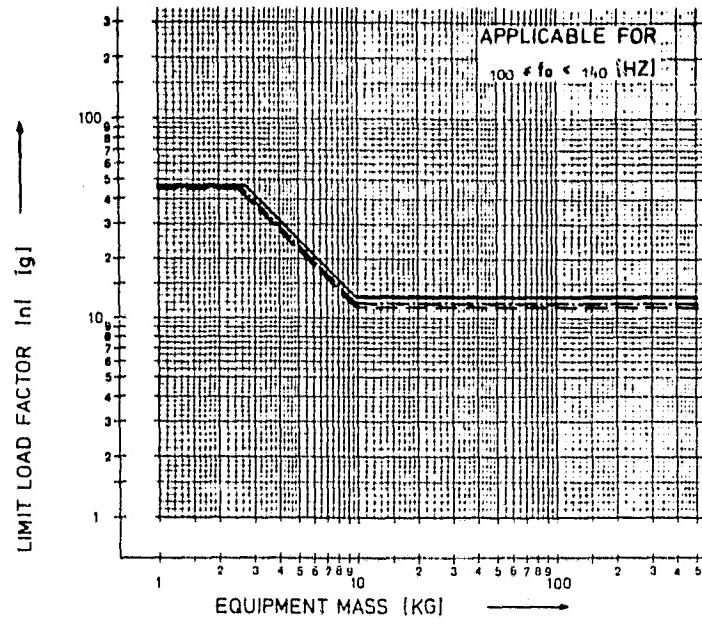
(see also para 3.2.7)

Figure 3.4- 9a : Limit Load Factor Diagram for Dimensioning of Brackets, Zone "Overhead Structure"

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$|n|$ ACTING AT
EQUIPMENT C.G.

j=1.0

($|n|$ = absolute values)

(see also para 3.2.7)

Figure 3.4- 9b : Limit Load Factor Diagram for Dimensioning of
Brackets, Zone "Overhead Structure"

3.5 Stowage Containers

3.5.1 Overhead Stowage Containers

Overhead Stowage Containers are located at and fastened to the overhead structure which is illustrated in relation to the module in Figures 3.5 - 1 and 2. The overhead stowage container consists of an outer container, which is fixed to the overhead structure, and an inner container, which can be slid out like a vertical drawer. Stringers inside the inner container provide for the attachment of experiment equipment by means of experimenter provided substructure. For film stowage purposes such a substructure, a Film Stowage Kit, is provided by Spacelab. This film stowage kit consists of separator sheets (shelves) and door-like restraints.

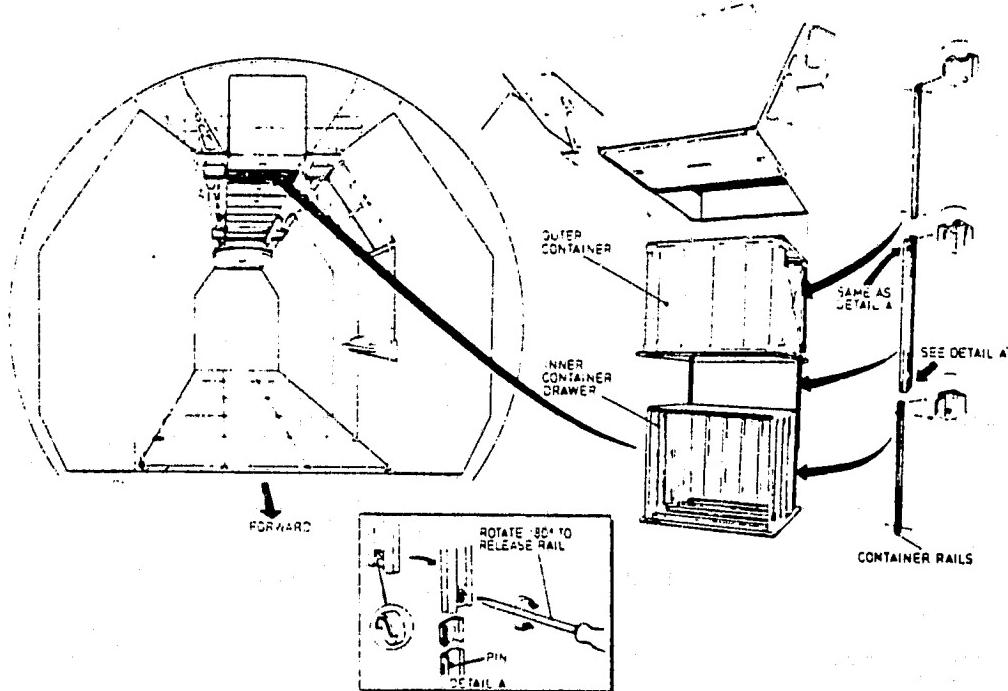


Figure 3.5 - 1: Overhead Stowage Containers

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3.5.1.1 Overhead Configuration

Depending on the actual CPSE installed in the module the overhead stowage containers can be flown in various configurations. In Figure 3.5 - 3 the standard overhead configurations are given for which all the necessary hardware, such as close-outs, light support structure etc, is provided by Spacelab.

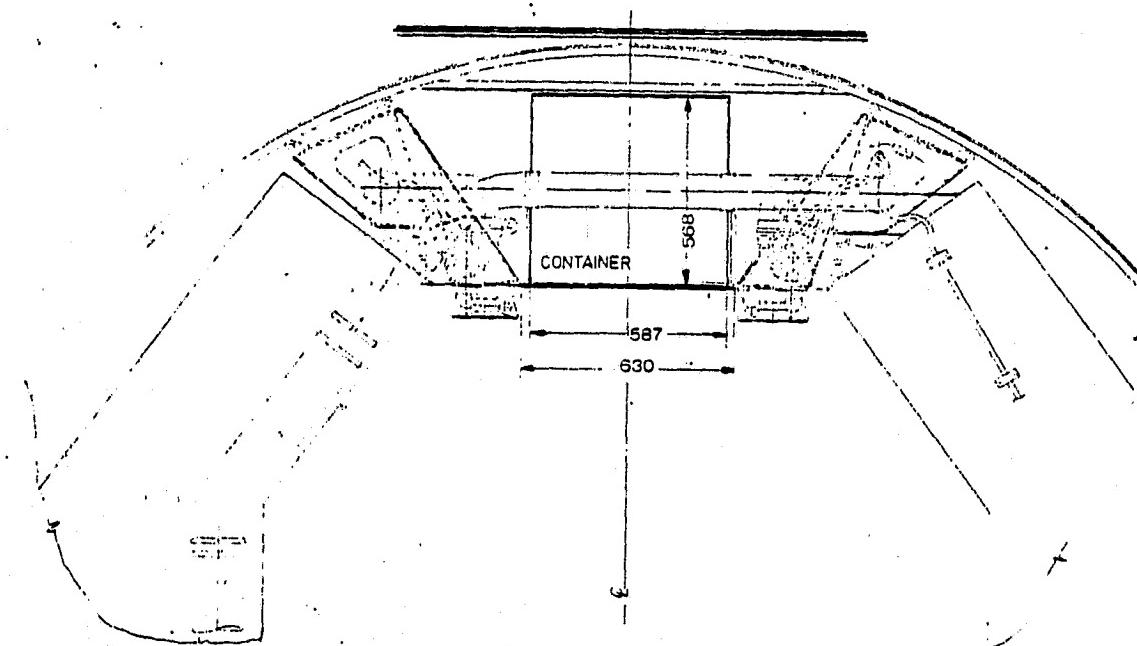
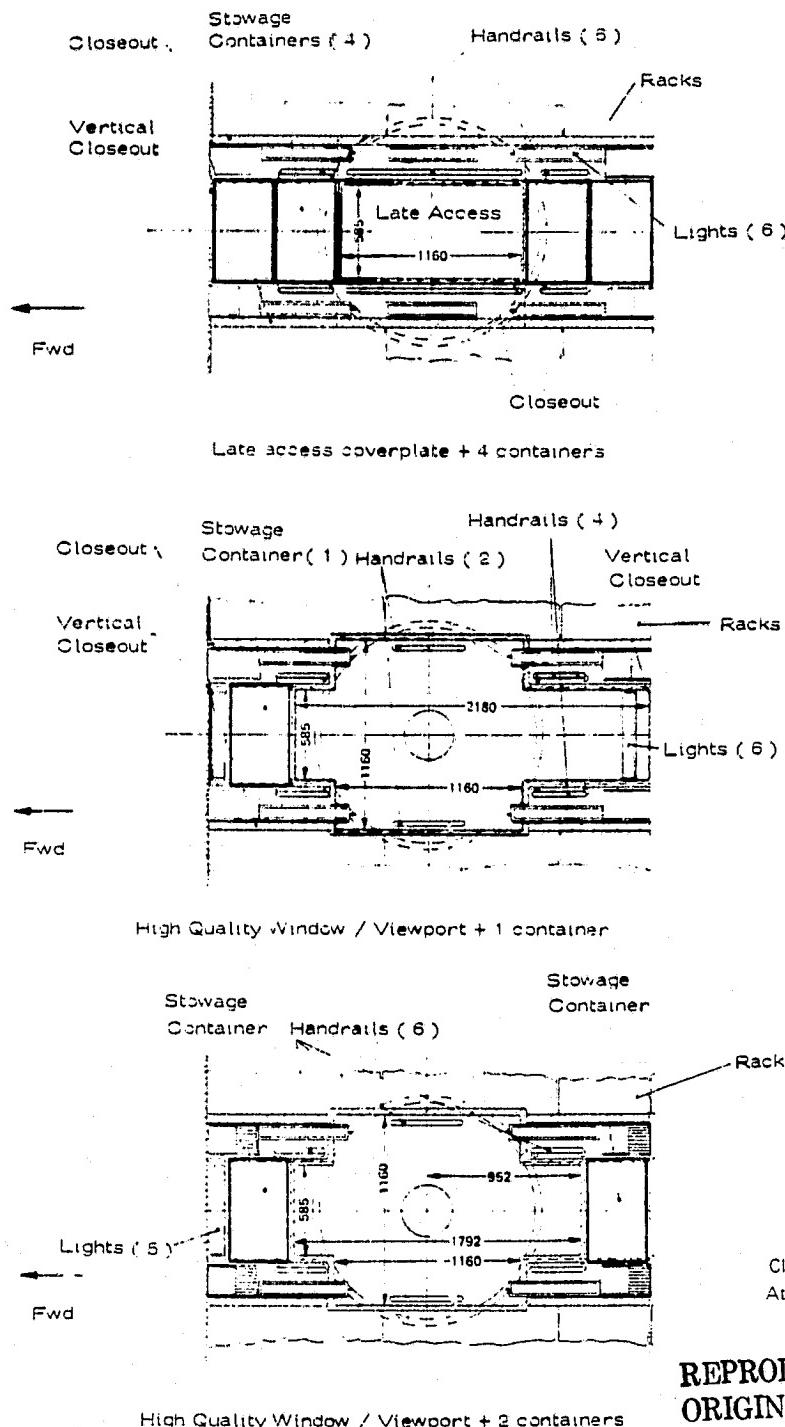


Figure 3.5 - 2 : Overhead Stowage Container

Core Segment

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Figure 3.5 - 3a: Standard Overhead Configurations for which closeouts are provided

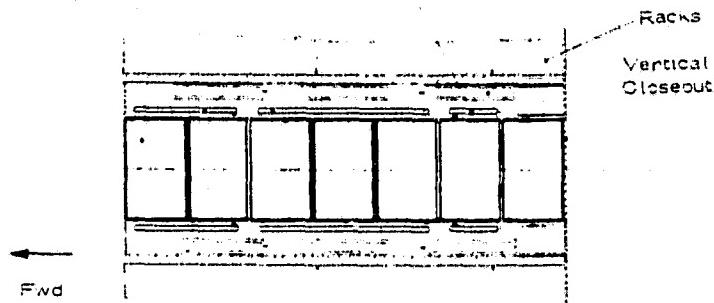
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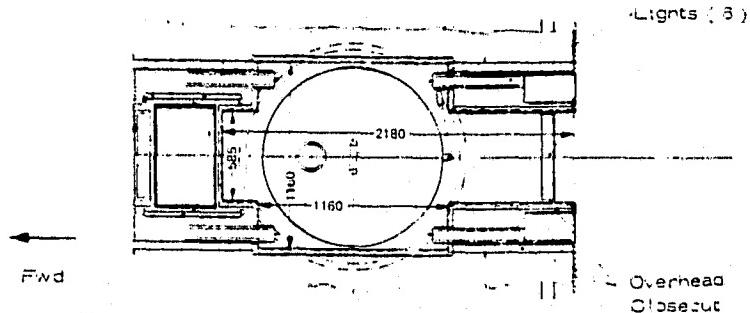
Experiment Segment

Stowage
Containers (7) Handrails (6) Lights (5)



7 containers, no CPSE

Handrails (2) Stowage
Container (1) - Racks



Airlock + 1 container

Closeout material - fabric
Attachment - velcro

Figure 3.5 - 3b: Standard Overhead Configurations for which closeouts are provided

3.5.1.2 Overhead Stowage Container Mechanical Interface

The outer stowage container consists of an outer frame mounted to the overhead attachments, and has only one side closed in the flight direction, as shown in Figure 3.4 - 4. The inner stowage container is designed as a drawer of the outer container, as shown in the container build-up in Figure 3.5 - 1.

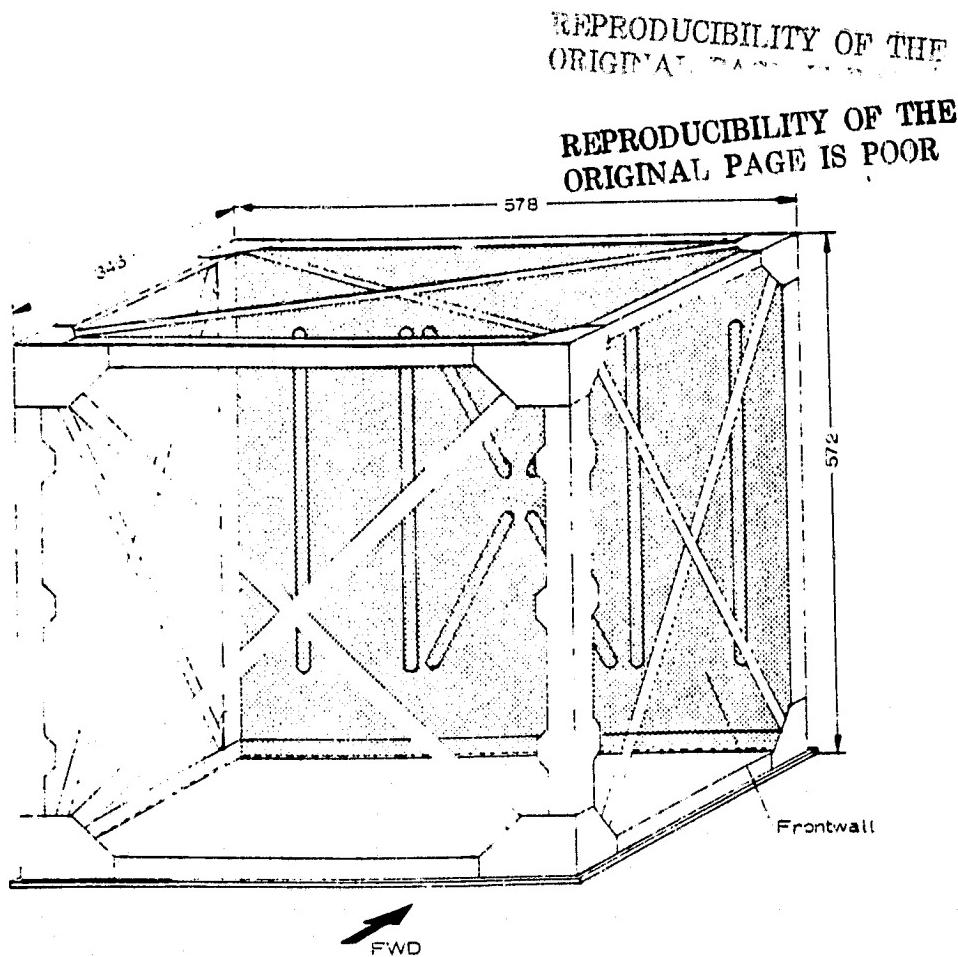


Figure 3.5-4: Outer Container - View from Backside

The payload envelope of the inner container is given in Figure 3.5-5. All walls except the bottom plate have U-shape stringers with experiment attachment holes. Experiment equipment will be mounted to these holes by means of experimenter provided M5 bolts and nuts. Only where the holes are not accessible from the outside captive M5 are nuts provided.

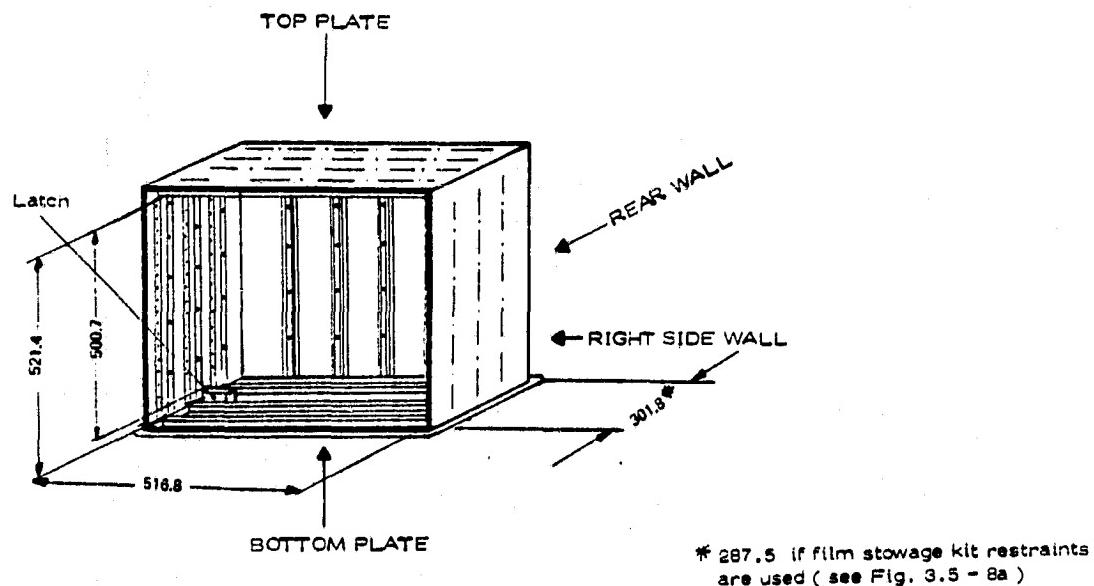


Figure 3.5-5: Container Payload Envelope

The attachment hole pattern is defined in Figure 3.5-6a to 3.5-6d .

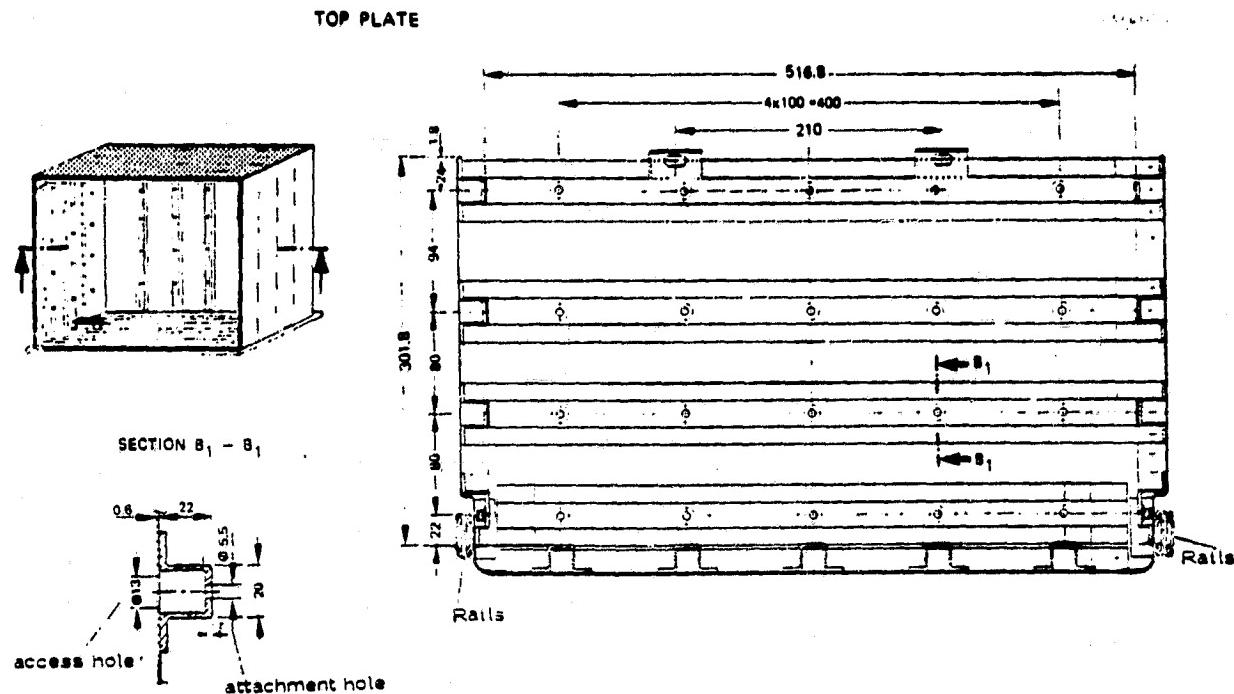
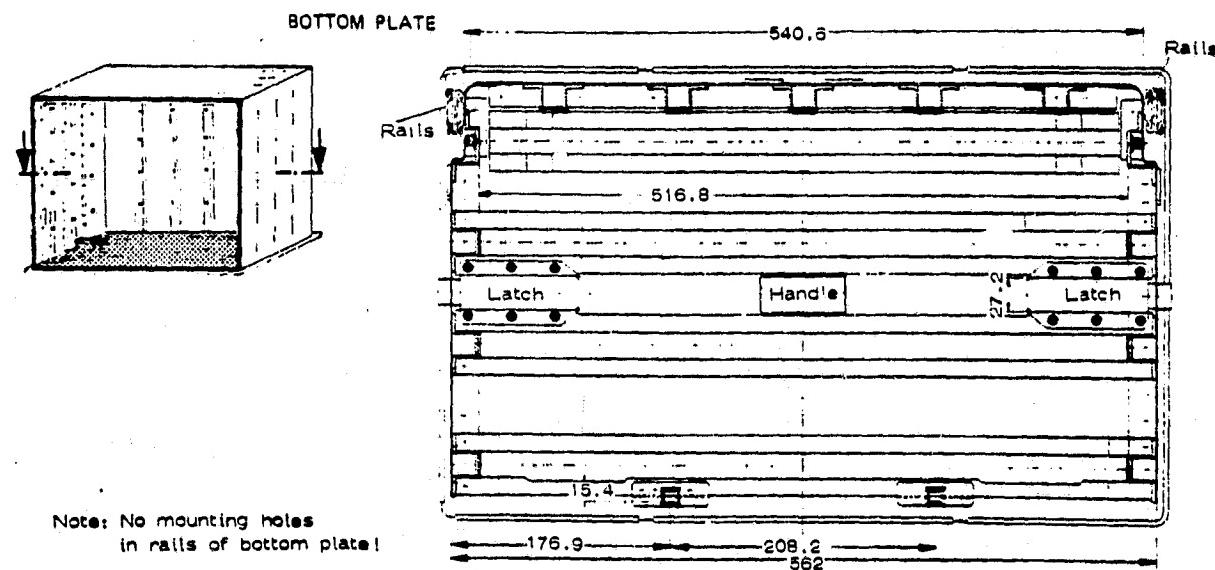


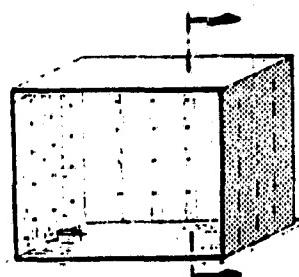
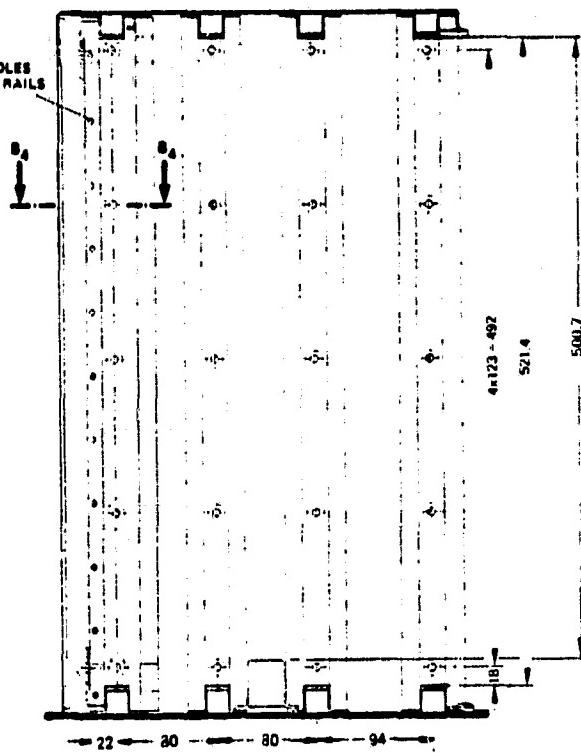
Figure 3.5 - 6a : Inner Container - Attachment Provisions - Top Plate



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Figure 3.5 - 6b : Inner Container - Attachment Provisions - Bottom Plate

SIDE WALL

MOUNTING HOLES
FOR DRAWER RAILS

CAPTIVE NUTS M6

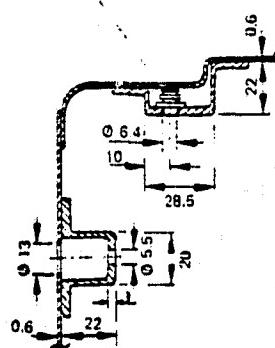
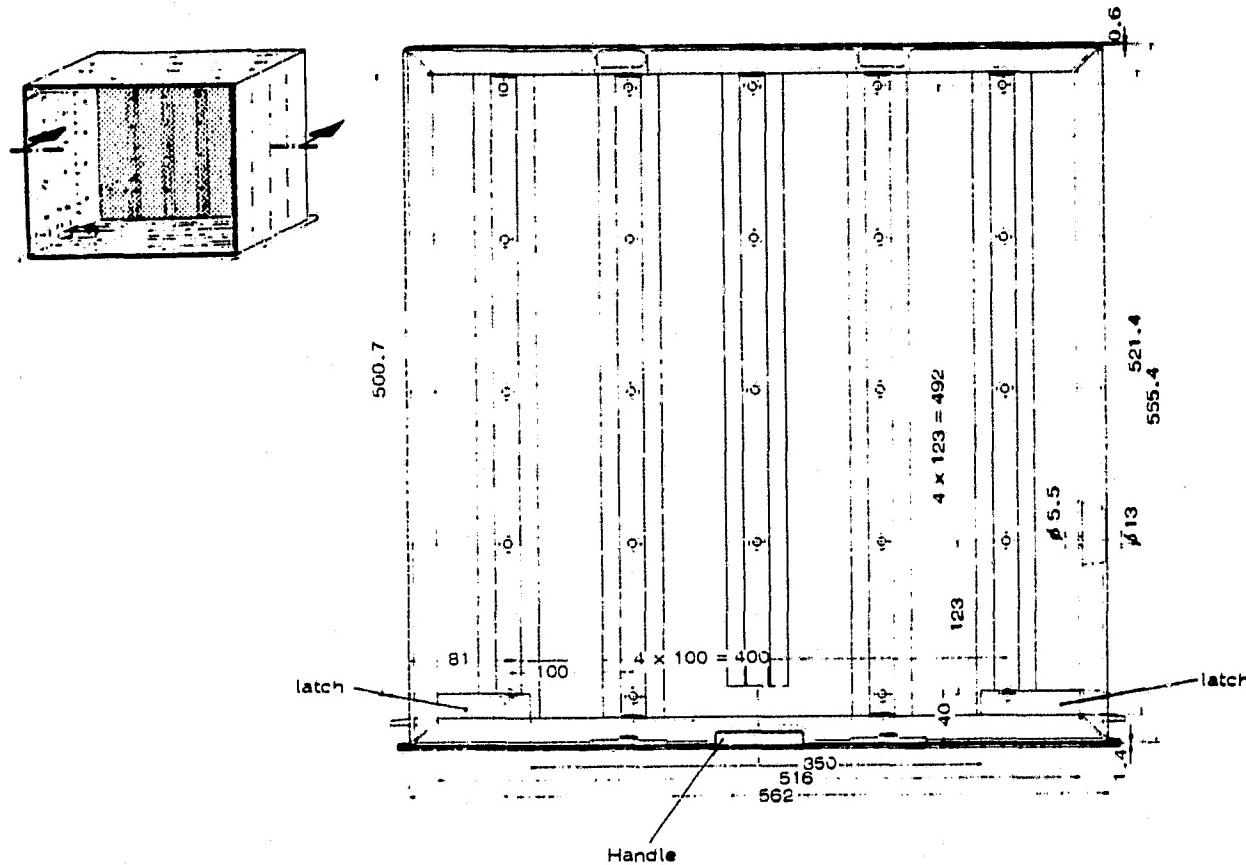
SECTION B₄ - B₄

Figure 3.5-6c: Inner Container-Attachment Provisions - Side Walls

REAR WALL



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Figure 3.5 - 6d: Inner Container - Attachment Provisions - Rear Wall

3.5.1.3 Overhead Container Film Stowage Kit

Each film stowage kit consists of

- restraints, i.e. hinged doors which restrain films in the container but still allow a view to container contents
- top and bottom cover which provide a flat surface inside the container
- adapter plates which are additional side walls having slits with a pitch of 12.3 mm
- separator sheets which are metal sheets sliding into the slits of the adapter plates

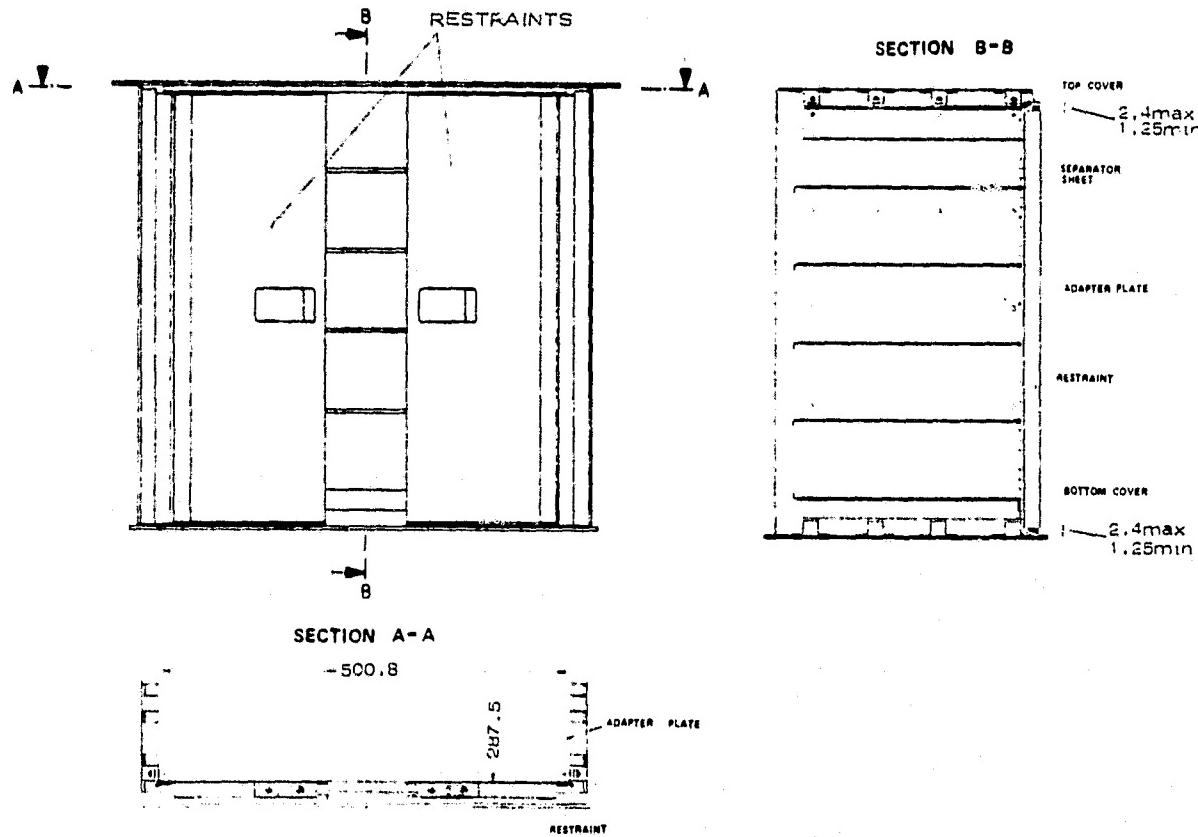
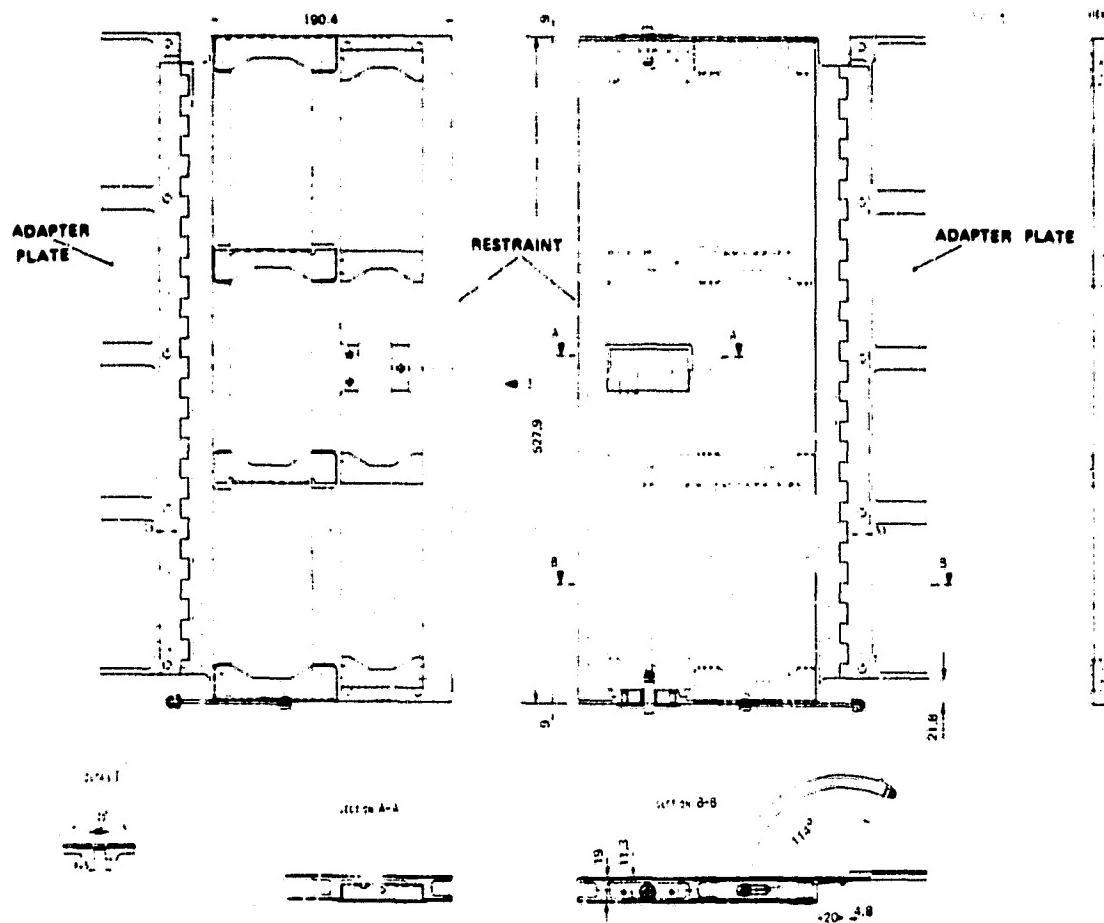


Figure 3.5-7a: Film Stowage Kit - Overview

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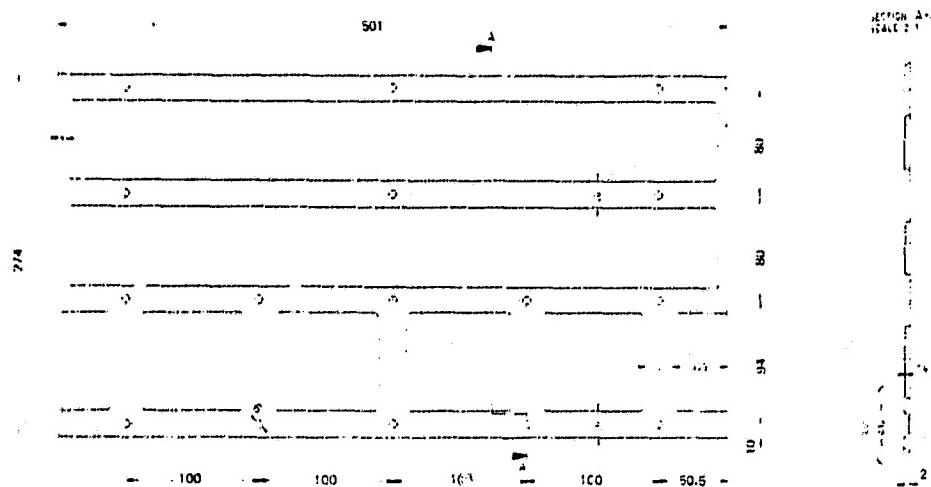
Figure 3.5-7b: Film Stowage Kit - Restraints

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TOP COVER



BOTTOM COVER

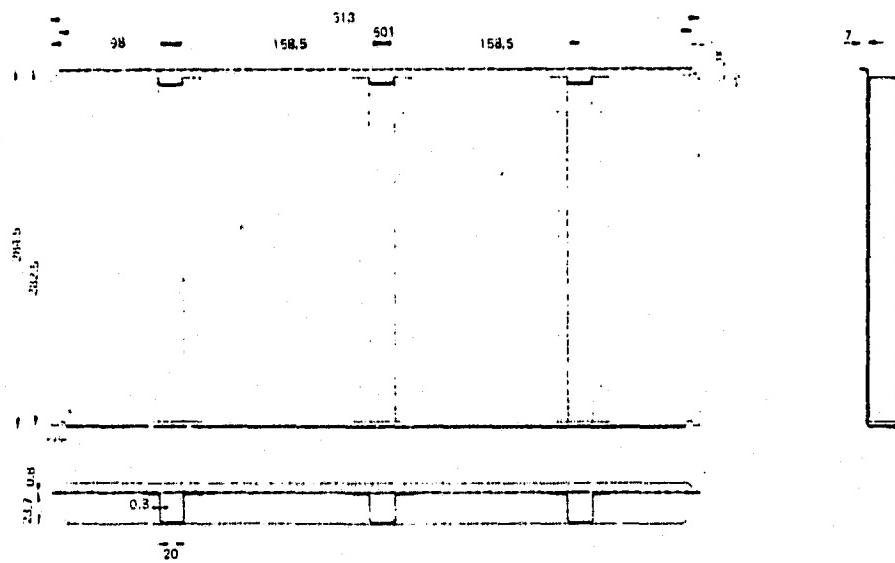
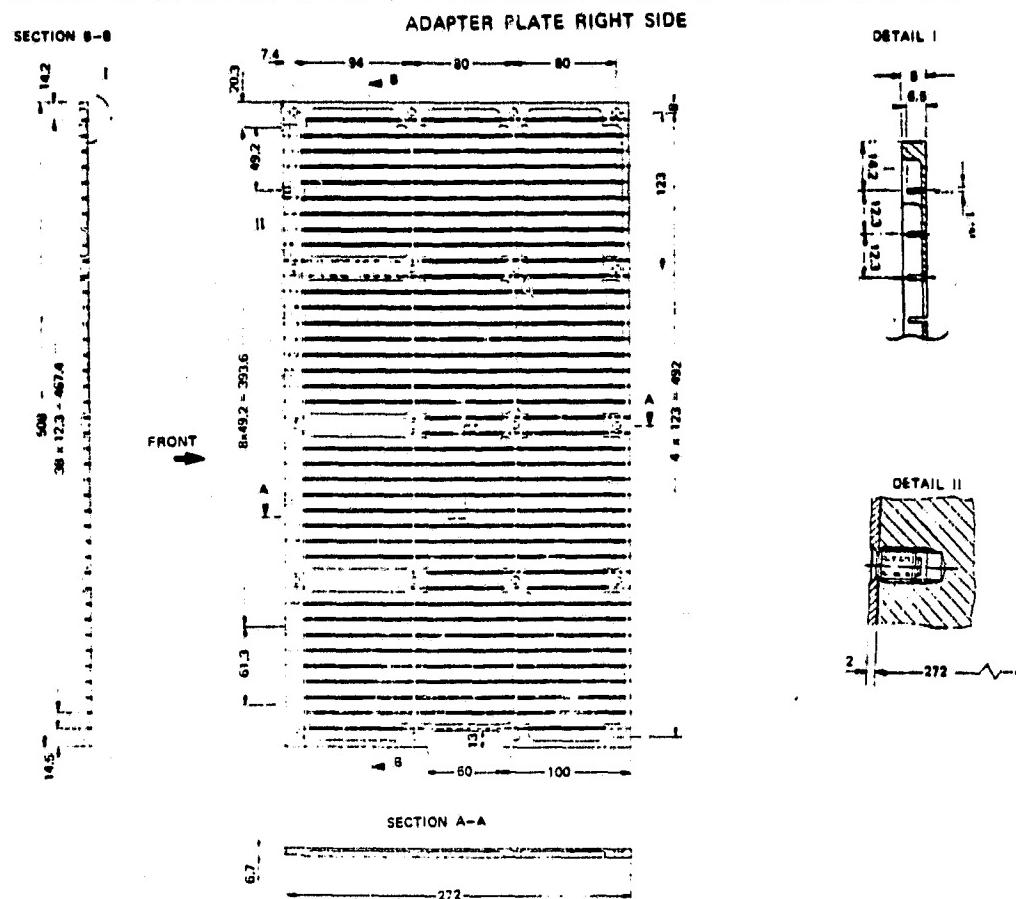


Figure 3.5-1c; Film Stowage Kit - Top and Bottom Cover

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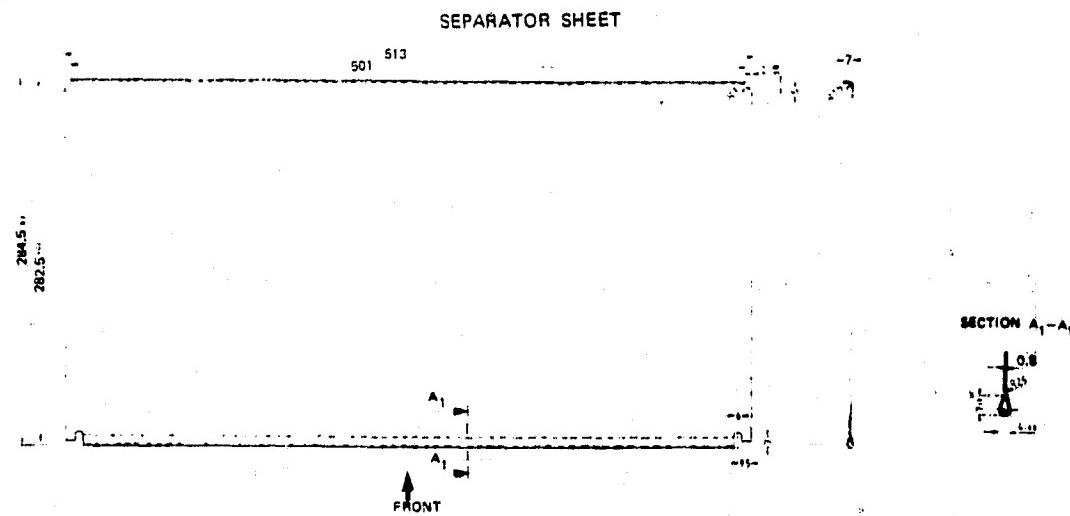


Figure 3.5-7d: Film Stowage Kit - Adapter Plate and Separator Sheet.

3.5.1.4 Load Carrying Capability of Overhead Stowage Containers

A total mass of 33.5 kg, distributed within the overhead stowage container, corresponding to a mass/volume ratio of 650 kg/m³, can be accommodated under the following local constraints:

- Max. load carrying capability per stringer = 16 kg
- Max. load carrying capability per attachment point (see Fig. 3.5-6a, b and c) is limited on which, and how many, of the five attachment points of a stringer (P_1 to P_5) are used. See table 3.5-1.

For adequate mass fixation, at least two stringers and three fixation points are to be used.

Table 3.5 - 1: Allowable masses for local loading of stringers (c.g. max. distance 40 mm)

Attachment Points Used					P_{max} (kg)
$P_1 (P_5)$	$P_2 (P_4)$	P_3	$P_4 (P_2)$	$P_5 (P_1)$	per attachment point
x	x				8.0
x	x	x			3.3
x	x	x	x		2.4
x	x	x	x	x	2.2
	x	x			3.6
	x	x	x		2.5



For dynamic response, the lowest permissible frequency of 35 Hz is to be observed for each mass point. Hence the maximum allowable c.g. distances from the wall of the masses to be accommodated are further constrained by this low-frequency requirement.

For instance, for two stringers 80 mm apart, the maximum allowable wall distance of the c.g. for an attached mass must not exceed 40 mm.

3.5.1.5 Mechanical Environment

The mechanical environment is as given in para. 3.4.6 - Overhead Structure.

3.5.2 Rack Stowage Container

Rack stowage containers can be mounted in the lower part of an experiment rack and also in the upper part of a rack if the cable tie down struts at the rear of the rack are removed. The substructure necessary to mount rack stowage containers into the lower or upper parts of a rack is provided by Spacelab. The containers can be turned around 180° to have the door either left or righthand hinged. Figure 3.5-6 gives an illustration of the containers located in the upper part of the rack. Substructures for mounting given in this section are designed for the smaller depth of the upper part of the rack. Mounting substructures for the lower portion of the rack, with greater depth, are similar.

Stringers inside the container walls provide for the attachment of experiment equipment by means of experiment provided substructure. For film stowage purposes such substructure, a Film Stowage Kit, is provided by Spacelab.

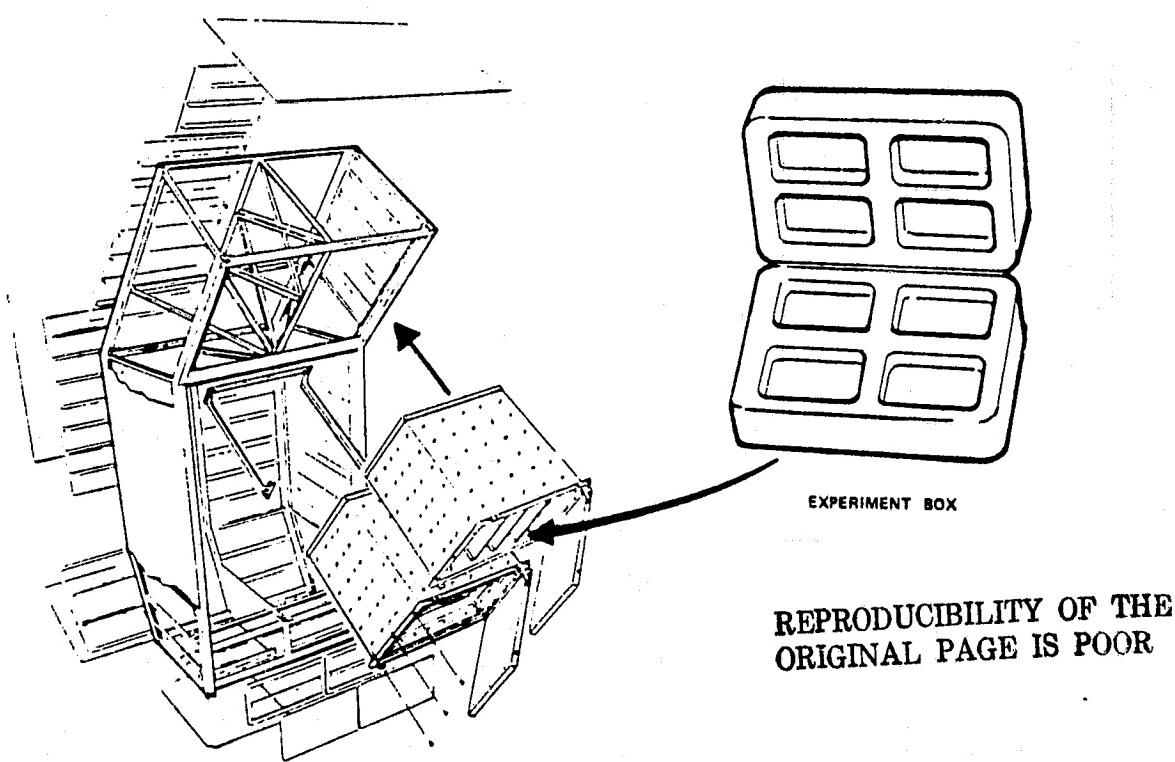


Figure 3.5 - 6 : Rack Stowage Container - exploded View

* Note: Spacelab provides four (4) sets of substructures for the lower part and four (4) sets for the accommodation in the upper part of the rack. The latter ones are used for the installation of the stowage containers in the work bench rack!

3.5.2.1 Accommodation Geometry

The envelope provided for the accommodation of payload equipment within the mounting stringers on both side walls, the rear wall, the top plate and bottom plate is shown in Figure 3.5 - 9. It must be noted that envelope shown provides no dynamic clearance for payload.

A general view showing the external features of the rack stowage container, including the rack mounting substructure, is shown in Figures 3.5 - 8 and 11.

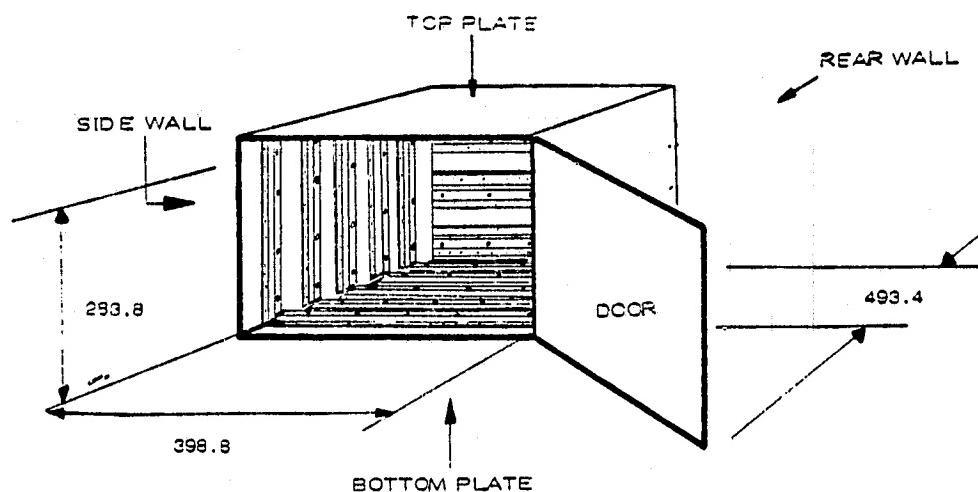


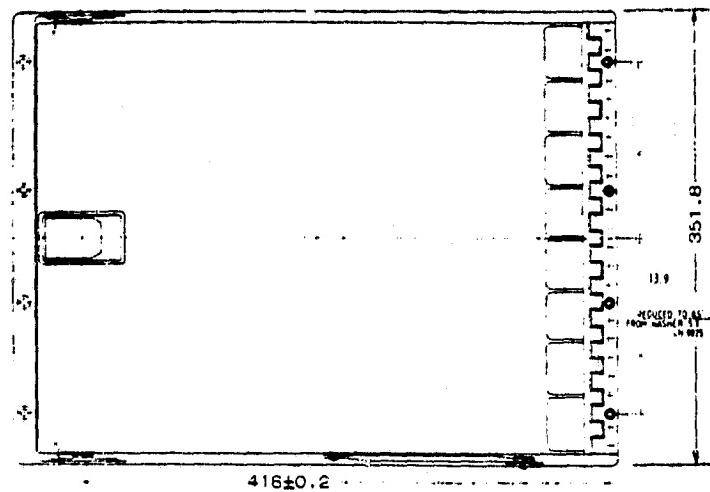
Figure 3.5-9 : Payload Envelope

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VIEW I



VIEW II

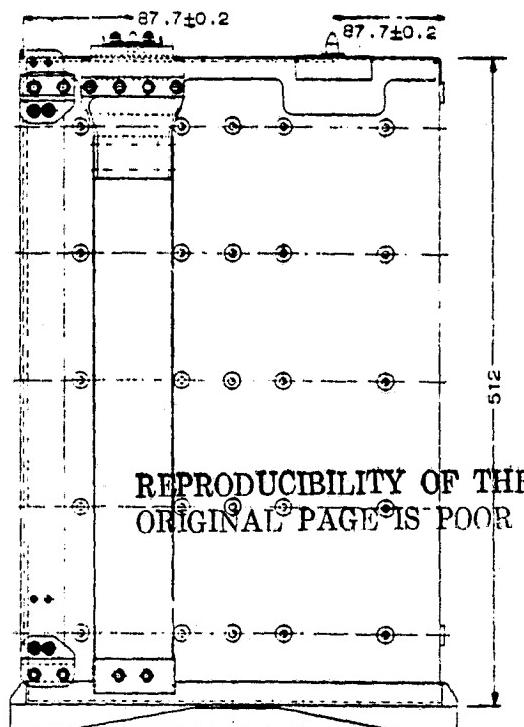
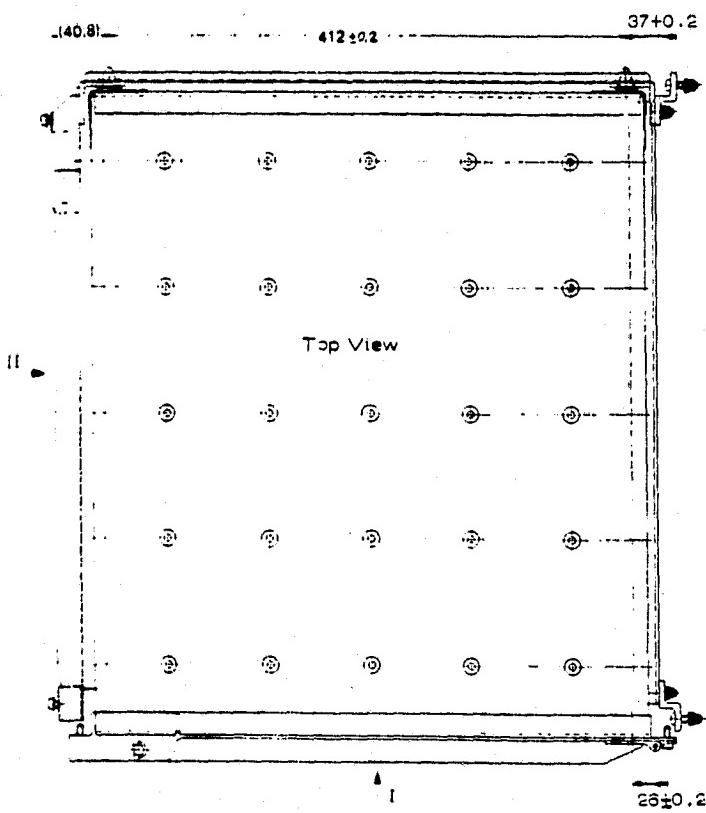


Figure 3.5-10: Rack Stowage Container—View Outside.

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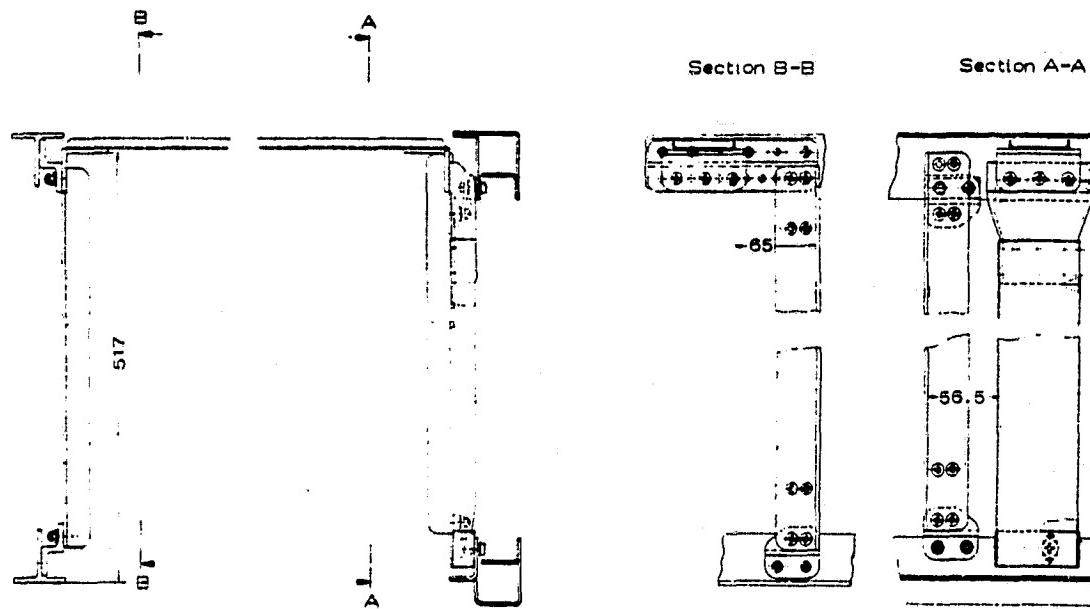


Figure 3.5 - 11 a : Guide Frame Right Side of Double Rack (Upper Part)

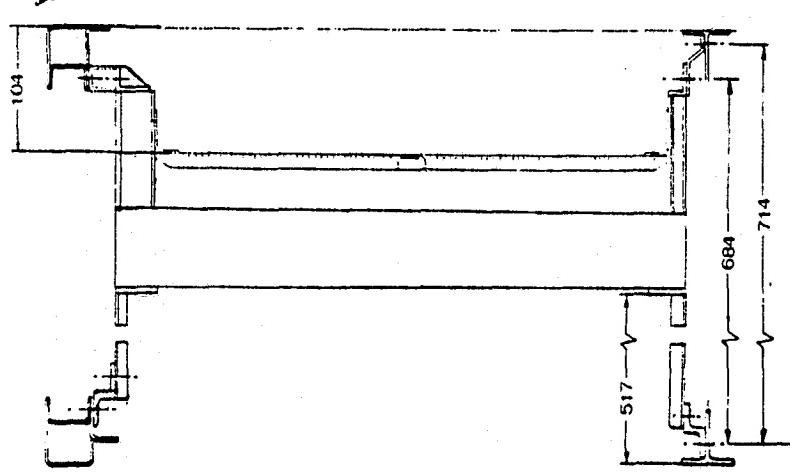
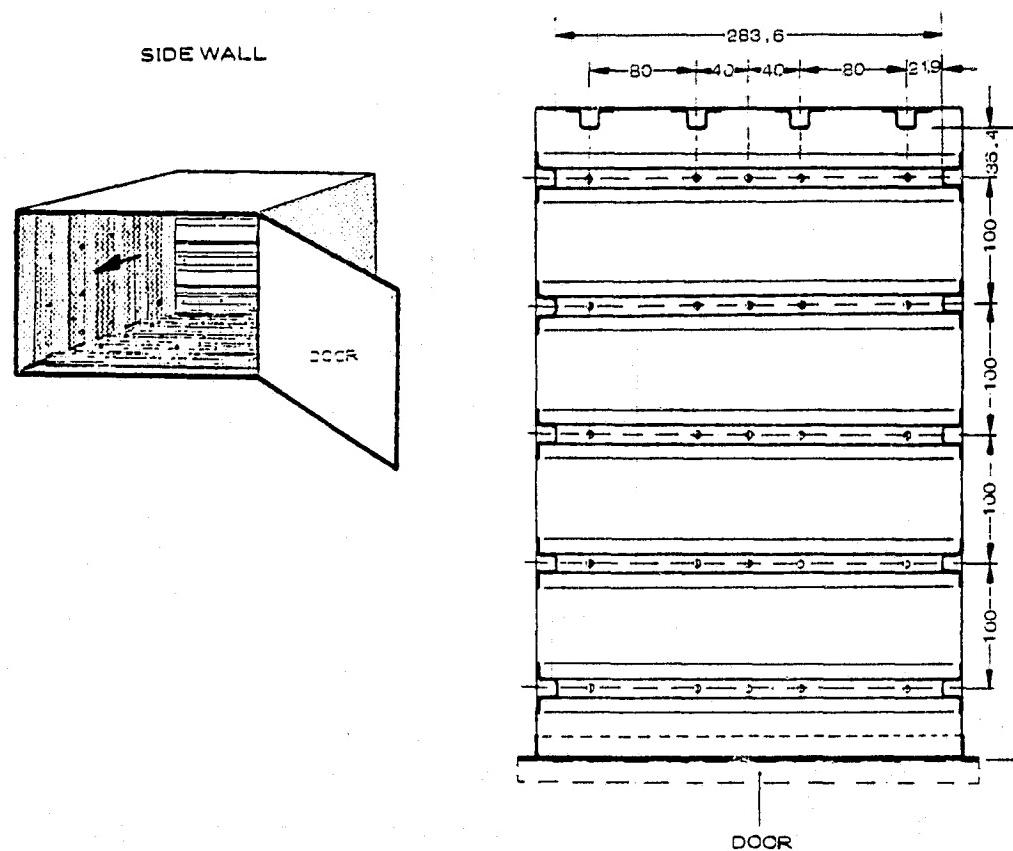


Figure 3.5 - 11 b : Guide Frame Left Side of Double Rack (Lower Part)

3.5.2.2 Experiment Attachment Interface

All walls of the rack stowage container have U-shaped stringers at the inside with experiment attachment holes. Experiment equipment will be mounted to these holes by means of experimenter provided M5 bolts and nuts. It should be noted that the actual mounting to the attachment holes requires access to the outside of the container.



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Figure 3.5-12: Rack Stowage Container Attachment Provisions.

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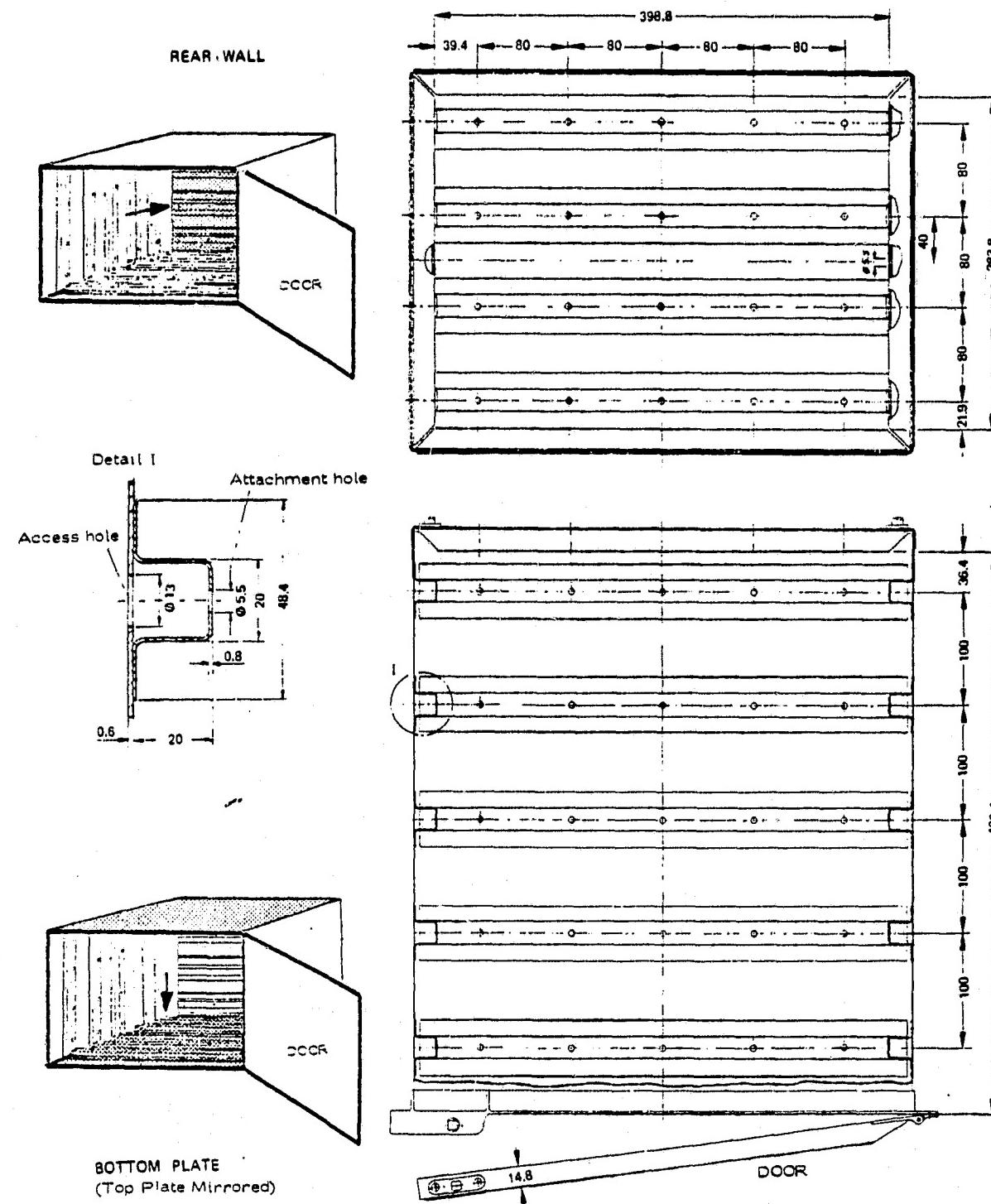


Figure 3.5-13: Rack Stowage Container Attachment Provisions

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3.5.2.3 Rack Container Film Stowage Kit

Each film stowage kit consists of

- top and bottom adapter plates which have slits with a pitch of 11.42 mm
- separator sheets which are thin metal sheets sliding into the slits of the adapter plates

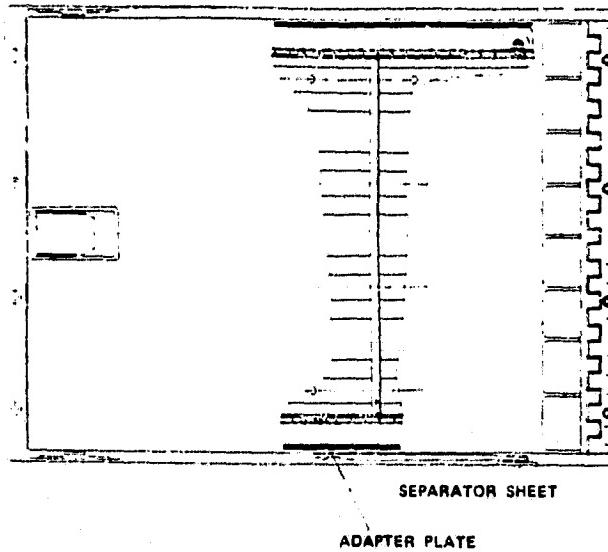


Figure 3.5-14: Rack Film Stowage Kit-Overview.

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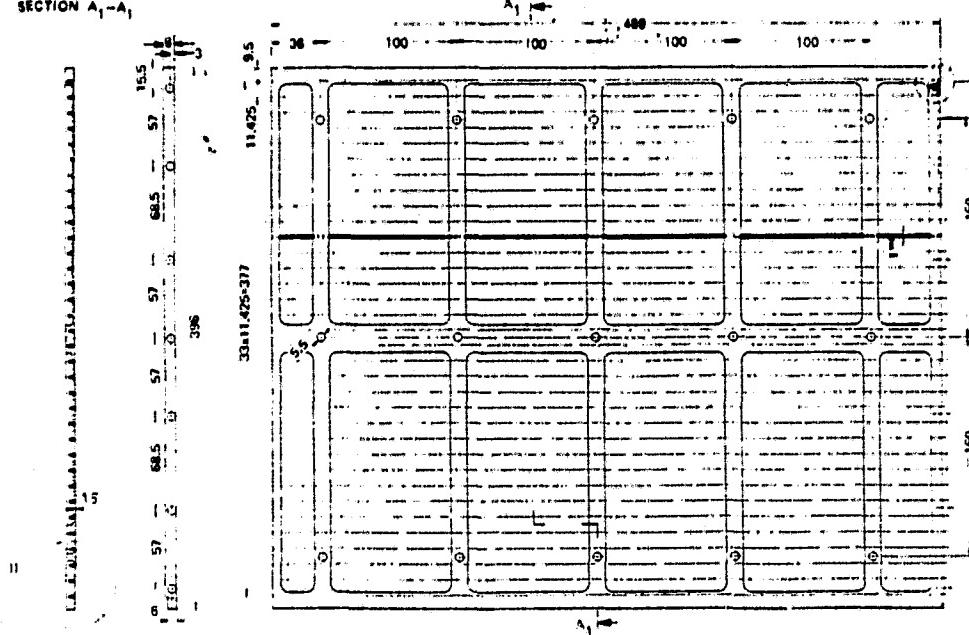
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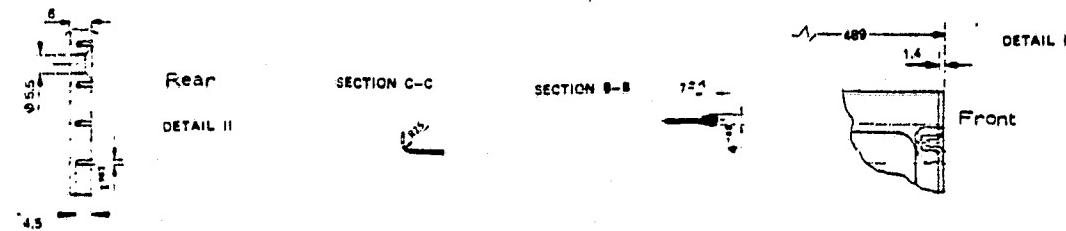
BOTTOM ADAPTER (Top Plate Mirrored)

SECTION A₁-A₁



A₁ ←

480



Rear

DETAIL II

SECTION C-C

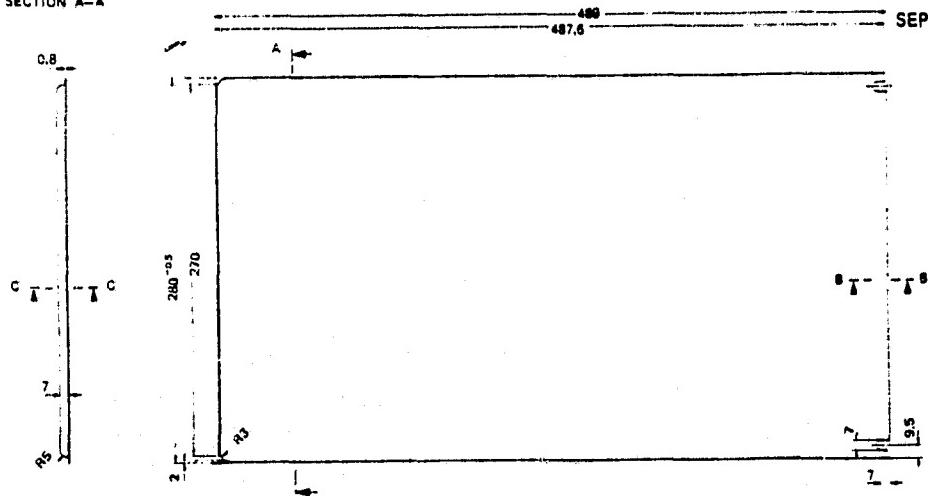
SECTION B-B

7.5

DETAIL I

Front

SECTION A-A



487.6

SEPARATOR SHEET

Figure 3.5-15: Film Storage Kit-Details

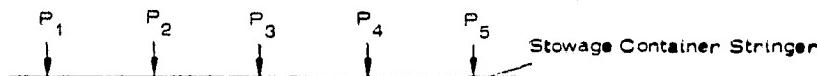
3.5.2.4 Load Carrying Capabilities of Rack Stowage Container

A total mass of 25 kg distributed within the rack stowage container, corresponding to a mass/volume ratio of 300 kg/m³, can be accommodated under the following local constraints:

- o Max. allowable wall distance of the c.g. for an attached mass must not exceed 50 mm
- o Max. load carrying capability per stringer = 7 kg
- o Max. load carrying capability per attachment point is limited, depending on which, and how many, of the five attachment points of a stringer (P_1 to P_5) are used. See table 3.5-2.

Table 3.5 - 2: Allowable Masses for Local Loading of Stringers (c.g. distance max. 50 mm)

Attachment Points Used					P_{max} (kg) per attachment point
x	x				3.5
x	x	x			1.9
x	x	x	x		1.4
x	x	x	x	x	1.2
x	x				2.4
x	x	x			1.7



For dynamic response, the lowest permissible frequency of 35 Hz is to be observed for each mass point. Hence the maximum allowable c.g. distances from the wall of the masses to be accommodated are further constrained by this low frequency requirement.

For instance, for two stringers at a distance of 80 mm, the maximum allowable wall distance of the c.g. for an attached mass must not exceed 40 mm.

3.5.2.5 Mechanical Environment

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The mechanical environment for the rack stowage containers is described in para. 3.1.8, Rack Mechanical Environment and is the same as for other rack mounted equipment.

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3.6 Common Payload Support Equipment

3.6.1 Airlock

3.6.1.1 Accommodation Geometry

The overall dimensions of the airlock and the dynamic payload envelope are defined in Figure 3.6 - 1 and 3.6 - 2.

The airlock experiment table is shown in more detail in Figure 3.6 - 3.

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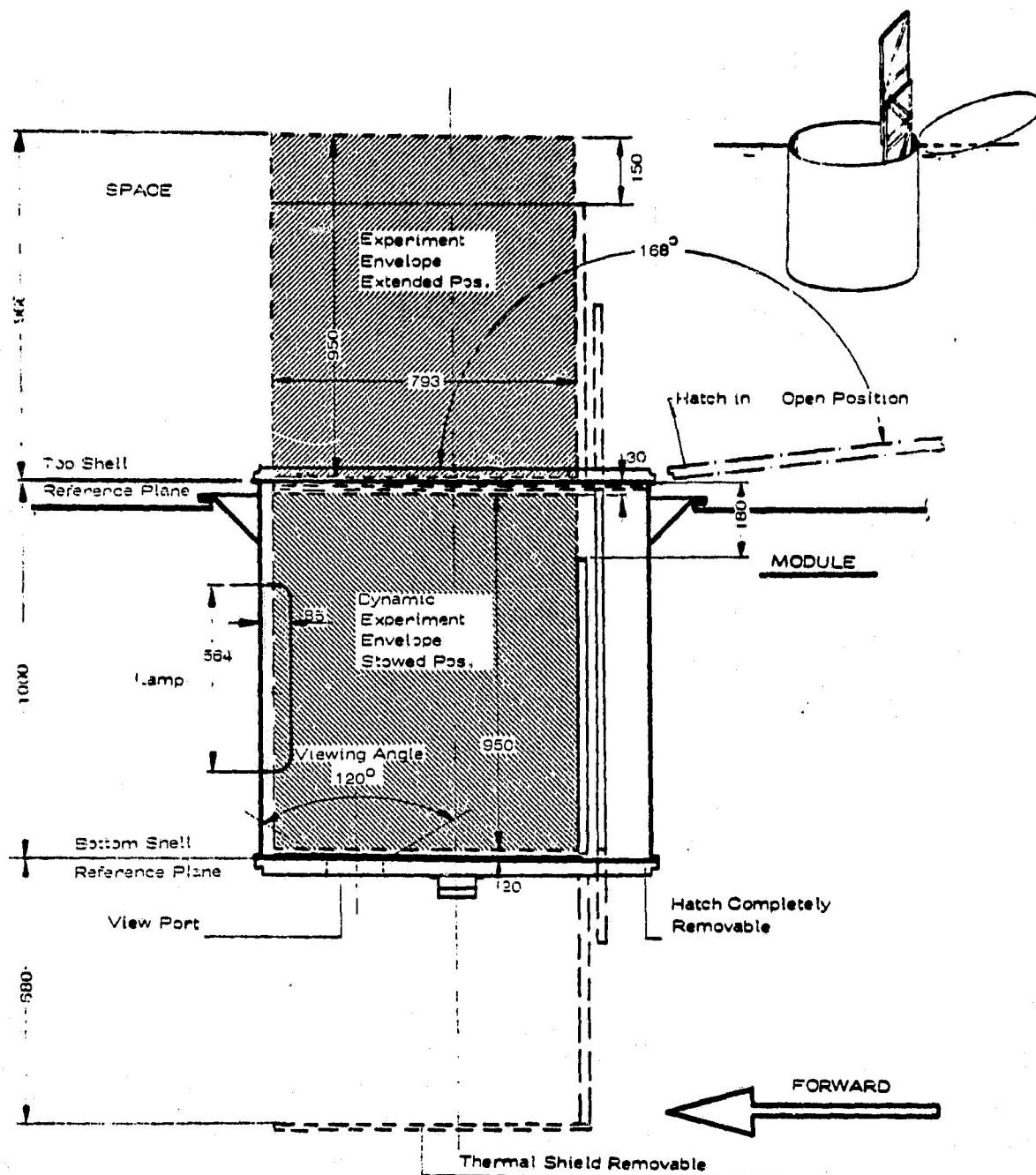


Figure 3.6 - 1 : Airlock - Experiment Envelope

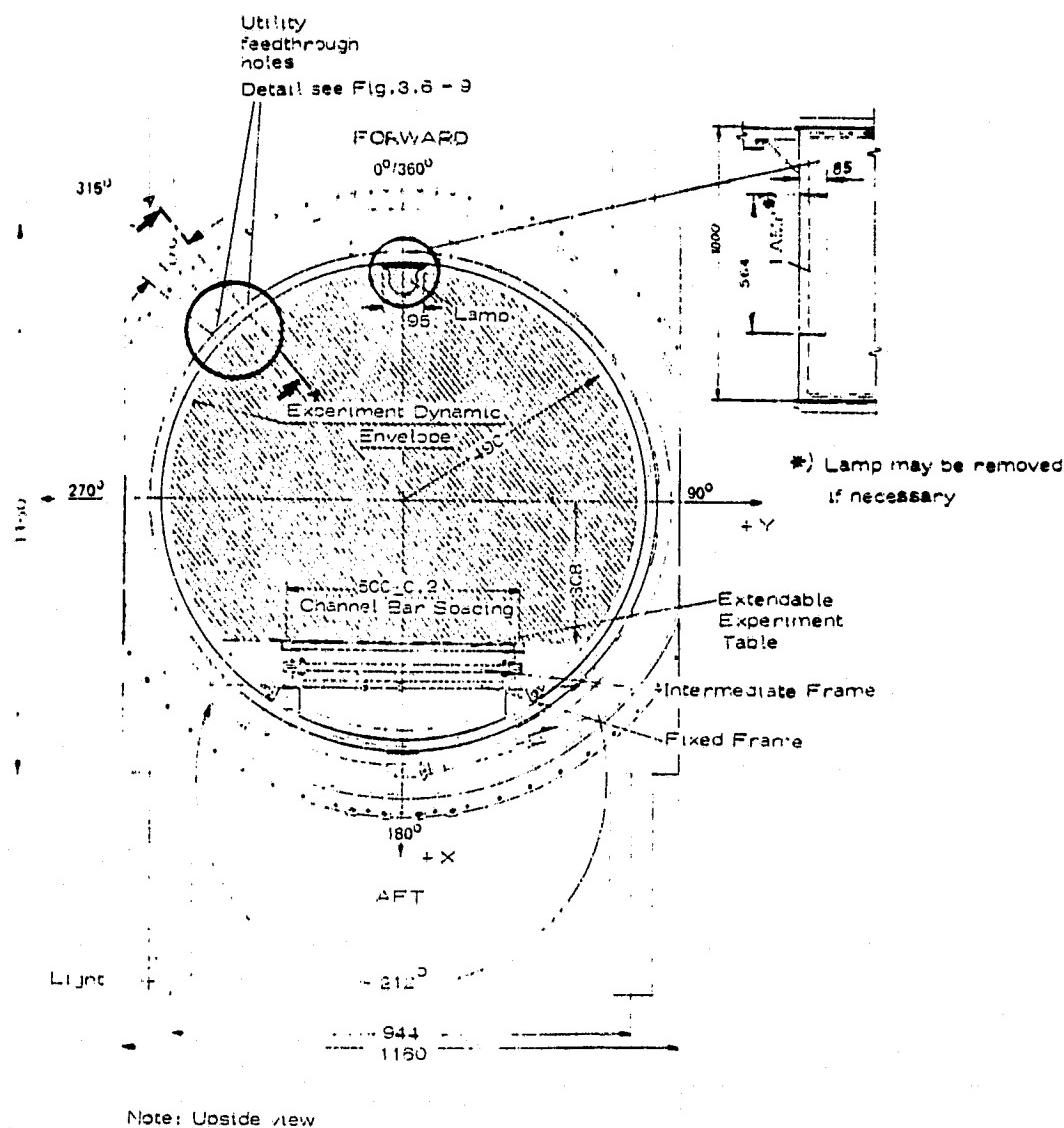


Figure 3.6 - 2 : Airlock-Experiment Envelope

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3.6.1.2 Experiment Attachment Interface

Experiments in the airlock have to be attached to the airlock experiment table (see Figure 3.6 - 3, 4 and 5). The experiment table has two channel bars in which four experimenter provided T - bolts slide and to which the experiment is tied down. Loads in the direction of the channel bars are taken by two experimenter provided pip pins (see Figure 3.6 - 7) which pass through holes in the channel bar and the T - bolts. The location of these holes along the channel is given in Figure 3.6 - 6.

As shown in Figure 3.6 - 4 and 5 the inner end of the experiment table carries a harness support bracket to tie down the loose pigtails of experiment harness I or experiment harness II respectively. The harness pigtailed including the plugs are attached to the support bracket by the use of quick release fasteners (see Figure 3.6 - 5) and mating dummy jacks.

Power and signal harness attached to the support bracket form separate bundles

- Experiment harness I (Figure 3.6 - 4)
RAU power harness: CBT-P1, PO1, PO2
Pigtails length: about 550 mm
Signal harness: PO3, PO4, PO5, P18
Pigtails length: about 750 mm
- Experiment harness II (Figure 3.6 - 5)
RAU power harness: CBT-P1, PO1, PO2
Pigtails length: about 550 mm
Signal harness: PO3
Pigtails length: about 750 mm

This harness support bracket can be removed only if the experiment provides for the tie down of the loose pigtails and the connectors.

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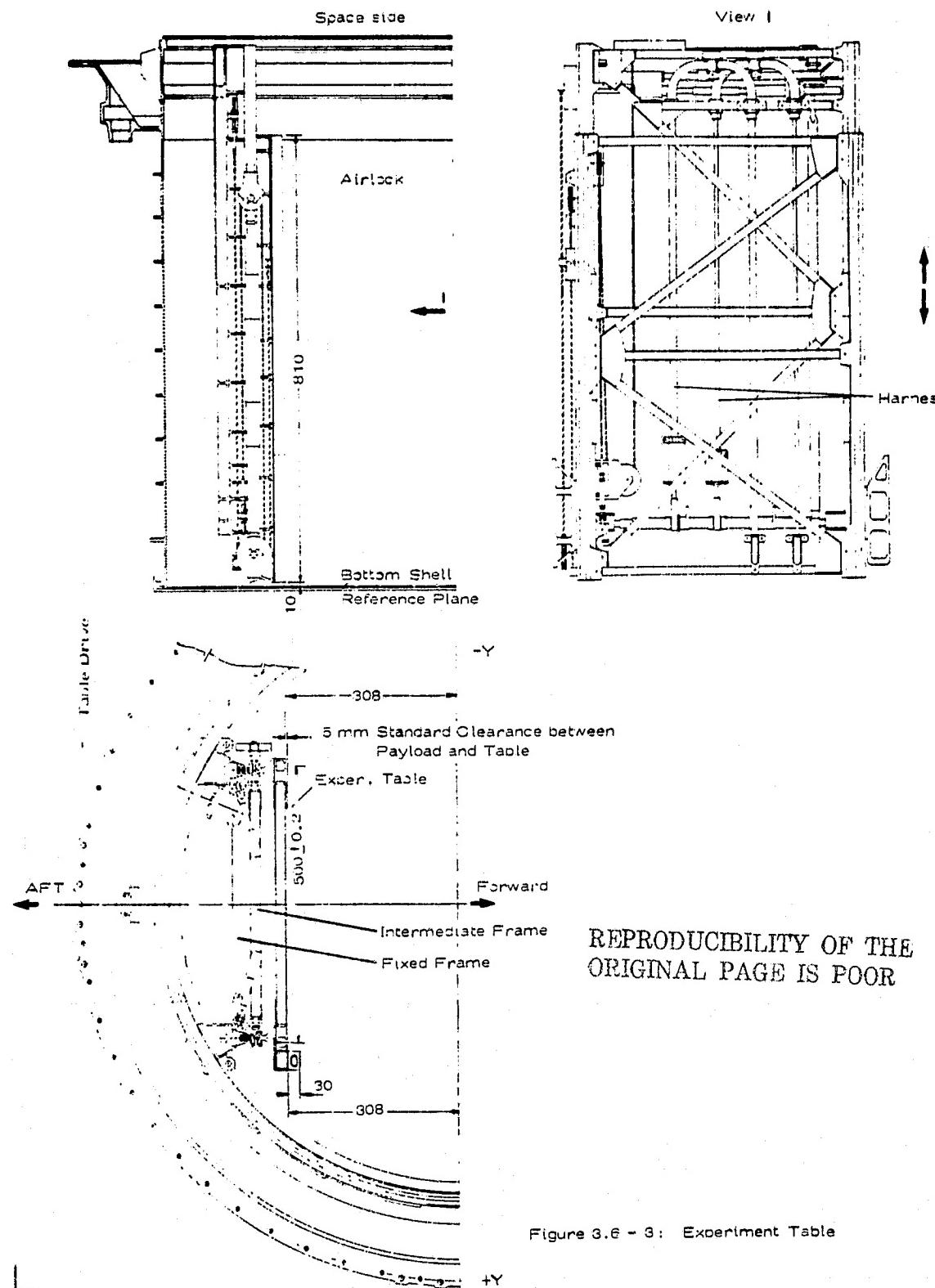


Figure B.6 - 3: Experiment Table

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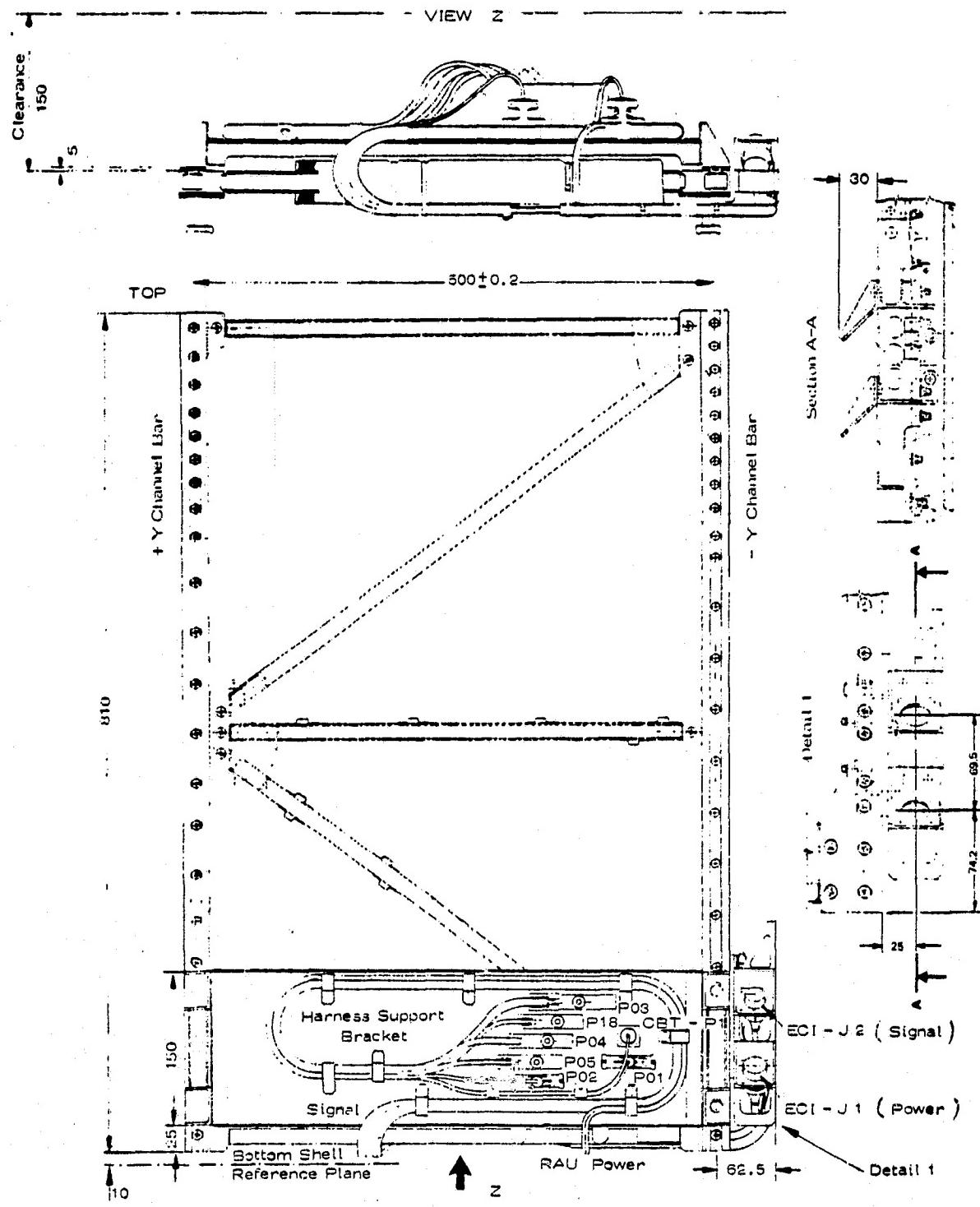


Figure 3.6 - 4 : Experiment Table with Support Bracket for Harness I

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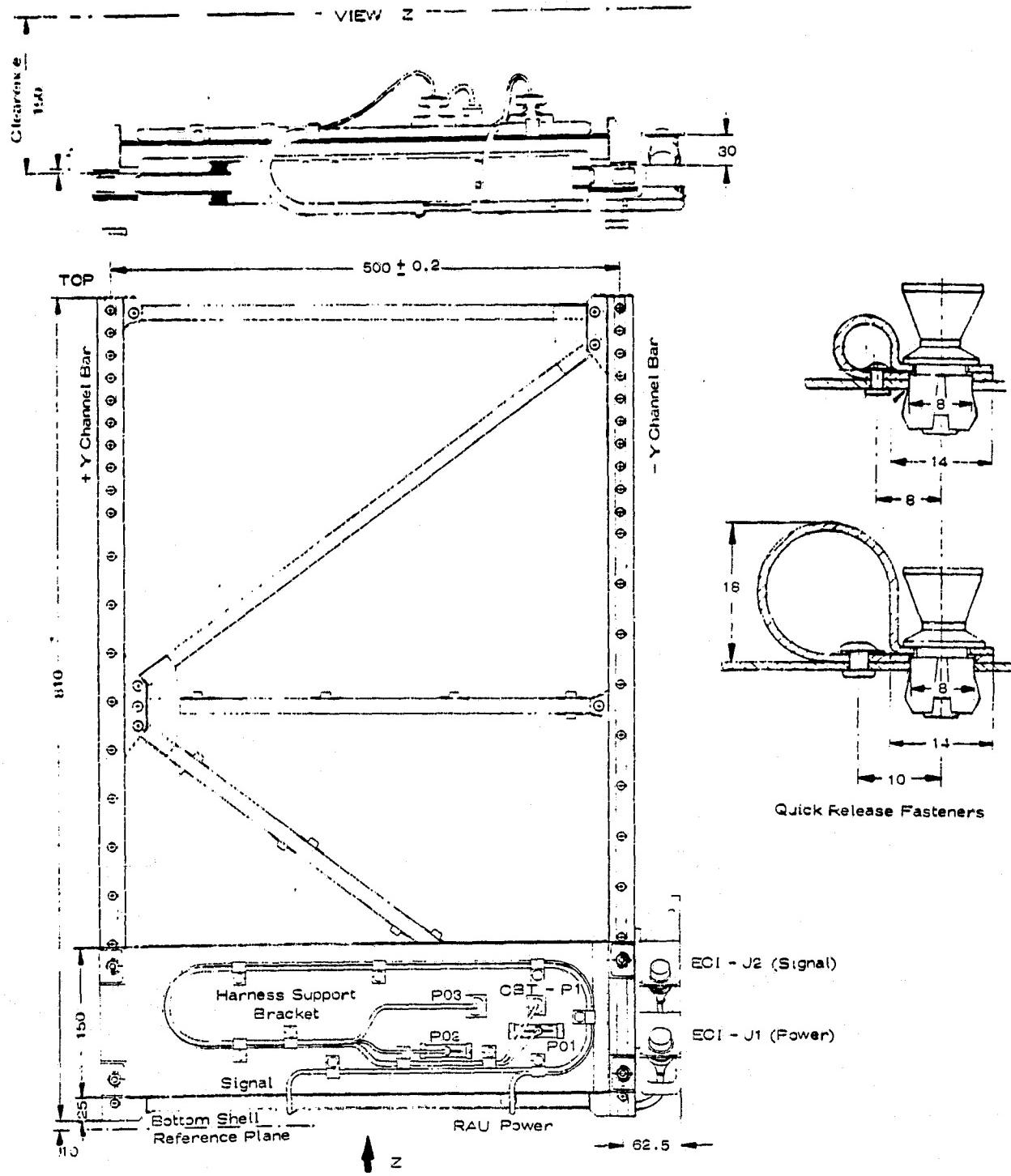
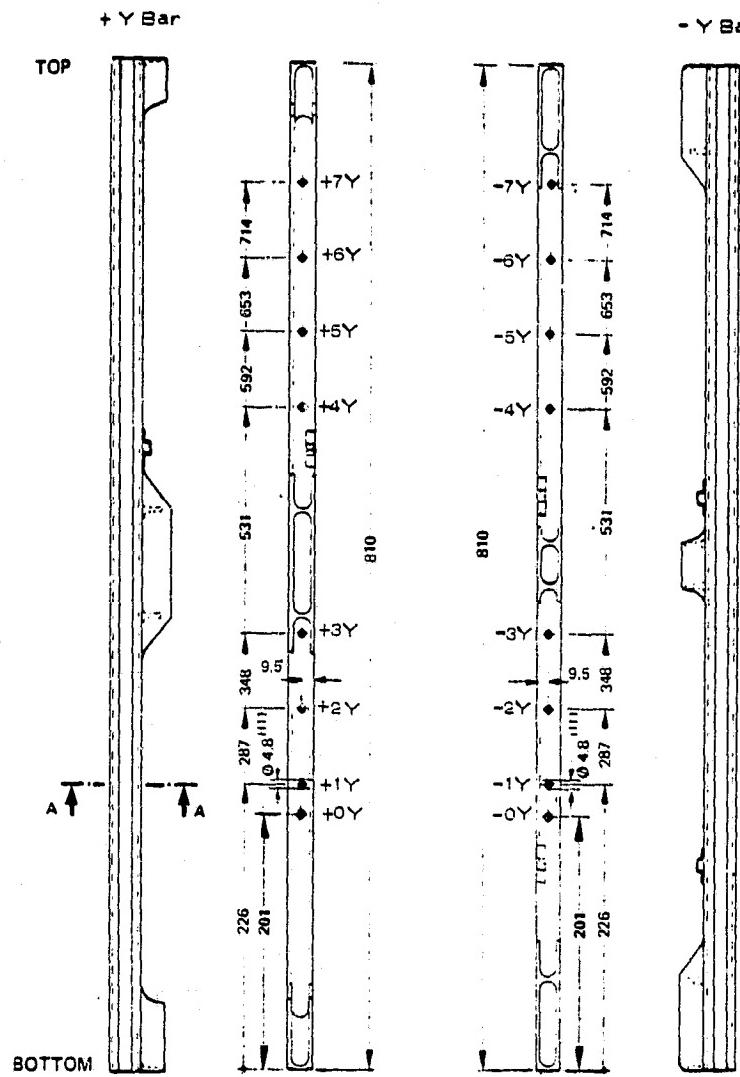


Figure 3.6 - 5 : Experiment Table with Support Bracket for Harness II



Note: ±1Y thru ±7Y are payload dedicated pip pin holes.
±0Y are reserved for the flexible signal harness support bracket.

Figure 3.6 - 6: Location of Pip Pin Holes

Figure 3.6 - 7 shows the detailed dimensions of user provided T-bolts and pip pins, which have to fit in the experiment table channel bars.

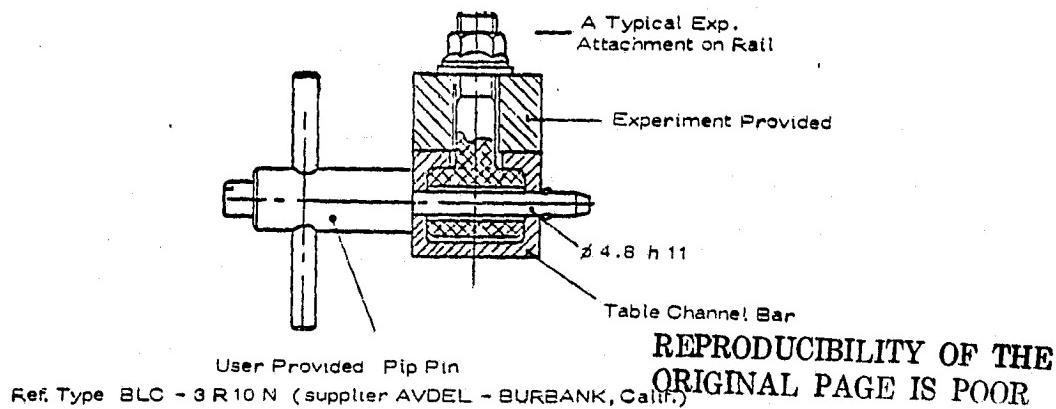
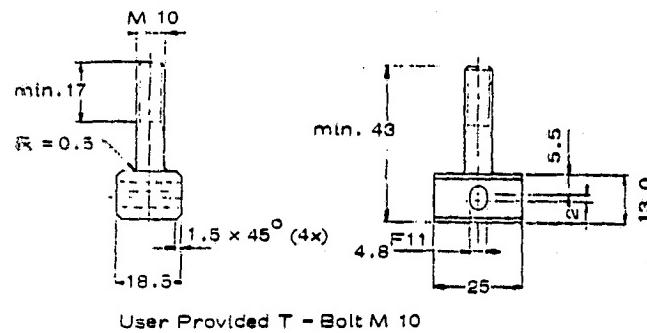
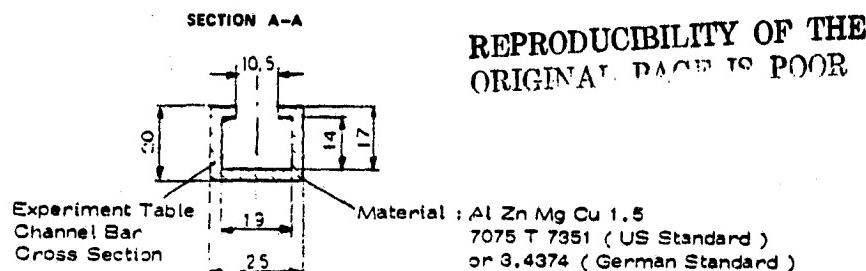


Figure 3.6 - 7 : Table Rail - Details

3.6.1.3 Attachment Interface Requirements

Requirements which ensure full load carrying capability.

- Experiments (or each individual piece of equipment) shall be mounted to the experiment table by at least four attachments; two attachments on the + Y channel bar and two on the - Y channel bar, equally spaced by at least 300 mm.
- One attachment on each rail shall be locked by a pin capable of transmitting loads in the direction of the channel bars.
- The projection of the c.g. of the experiment (or each individual piece of equipment) onto the experiment table plane shall be within the area defined by the four attachments.

Requirements which ensure the capability to retract or to jettison the experiment table (the Orbiter cargo bay doors cannot be closed when the experiment table is extended).

- Distortions of the experiment table introduced by the experiment shall be limited either in force or in local displacement; i.e., the force shall be less than 50 N perpendicular to the plane of the table or the local displacement shall be less than 0.5 mm out-of-plane. This is to ensure proper table extension and retraction operations. Even in failure cases, experiments shall - under no circumstances - introduce a force acting on the experiment table which is more than TBD N (tentatively about 10^3 N order of magnitude). This is to ensure proper jettison capability for the table and experiment.
- Experiments shall be thermally isolated from the experiment table such that the heat flow does not exceed TBD W per rail to avoid thermal deflection of the experiment table.
- If experiments deploy devices outside the experiment envelope of the airlock the deployment force and speed shall be such that:
 - a) no impact hazard exists at spontaneous deploy (during check-out or contingency EVA),
 - b) human intervention is possible in jamming cases (e.g., removal of obstructing elements during contingency EVA),
 - c) Maximum load for experiment configuration change of deployable devices shall not exceed 50 N (1/4 max. crew habitability load).

Requirements to ensure integrity of experiments and the airlock.

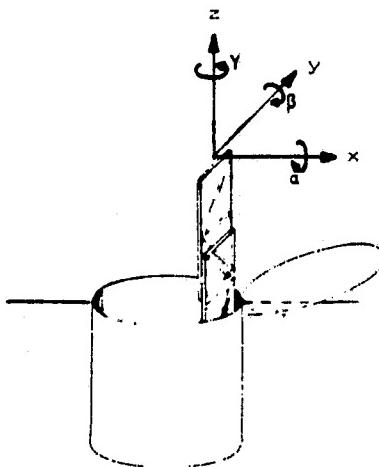
- The experiment shall be designed to withstand a shock of TBD when bumping against the extension stop.
- Loads applied to the free end of the extended or retracted table shall be such that the load component in the xy-plane is less than 500 N.

3.6.1.4 Alignment

The alignment accuracy of the airlock experiment table with reference to the module coordinate system is given in Table 3.6 - 1. These values have been calculated taking into account

- tolerances for play
- pressure effects on module and airlock
- temperature effects

Table 3.6 - 1: Alignment Accuracy of the Airlock Experiment Table



	mm			arc min		
	x	y	z	a	β	γ
Table stowed	±0.5	±0.6	+3.7 -0	±4.5	+3.1 -3.7	±6.2
Table deployed	+1.5 -1.4	±3.2	+5.2 -0	±23.0	+5.6 -6.2	±6.3

Note: These data are no specification values -

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3.6.1.5 EPDS / CDMS Interface

The EPDS / CDMS interface is at the extendable/retractable table itself as shown in Figure 3.6 - 4 and 5. The electrical characteristics of this interface are defined in Appendix A.

The electrical bonding has to be performed at the ty channel bar of the table which is at the drive side of the airlock (see Figure 3.6 - 8).

TOP VIEW AIRLOCK

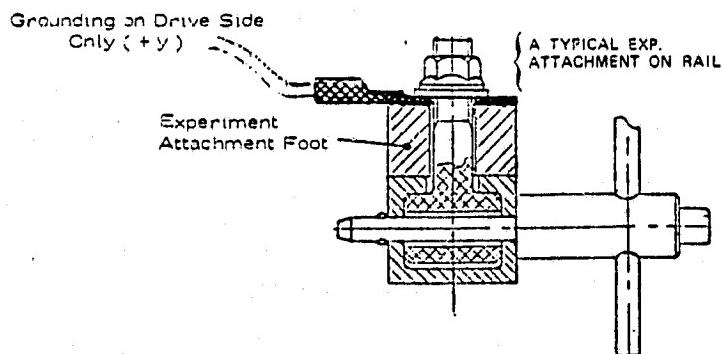
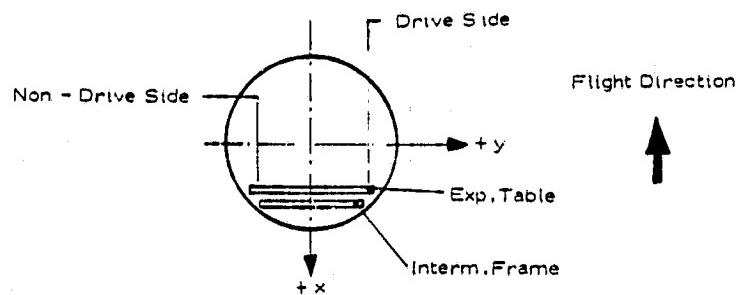


Figure 3.6 - 8 : Bonding Interface

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3.6.1.6

ECS Interfaces

The airlock does not provide ECS services to experiments. When extended into space thermal control has to be performed by means of passive thermal control and/or electrical heating.
When stowed in the airlock TSD W of experiment generated heat can be accommodated by the airlock.
When retracted into the module thermal control is provided by the cabin air loop.

The possibility exists to perform liquid cooling by user provided liquid cooling lines routed through the utility feedthrough holes in the airlock shell (see 3.6.1.7).

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3.6.1.7 Utility Routing

Two experiment dedicated utility feedthrough holes are located at the lower part of the airlock shell (see Figure 3.6 - 2). However, these holes have to be considered as a future extension capability rather than as a readily usable experiment interface. If the utility feedthrough holes are used the experimenter has to provide

- feedthrough connectors or fittings and associated cabling and plumbing
- guidance support of the utilities inside the airlock to enable proper operation of the experiment table
- a utility break device to enable emergency jettison of the experiment table if the experiment use of the airlock involves table extension into space.

Details of the utility feedthrough holes are given in Figure 3.6 - 9. Possible ways of routing utilities in the module to the airlock are shown in section 3.9.

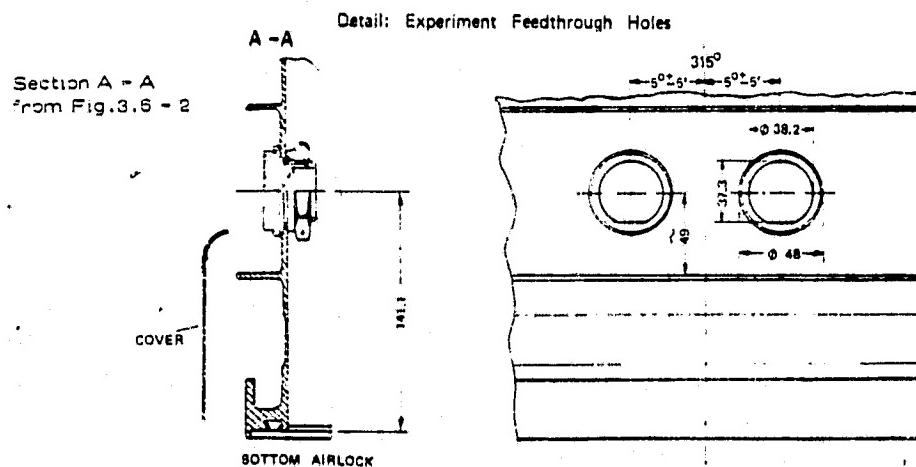


Figure 3.6 - 9 : Utility Feedthrough Holes

3.6.1.8 Experiment Table Load Carrying Capability

Local Loads

The allowable limit load for each experiment table attachment bolt is given in table 3.6 - 2.

Table 3.6 - 2: Allowable Limit Loads Per Attachment Bolt

	in X direct.	in Y direct.	in Z direct.
Allowable limit load in N	3500	640	2100

Overall Load Carrying Capability

The maximum experiment mass is 150 kg for on orbit operations
100 kg for ascent and descent

If no RAU is flown in the airlock, an additional independently mounted experiment mass of 10kg may be accommodated. These maximum values are only valid when experiments are attached in accordance with the mounting requirements defined in para 3.6.1.3.

When experiments with masses greater than 10kg are installed, experimenter provided MGSE is needed to support the experiment mass during installation on the table and for extension/retraction on the ground.

The c.g. constraints for the 100 kg payload installed during ascent and descent are given in Figure 3.6 - 10 and 11.

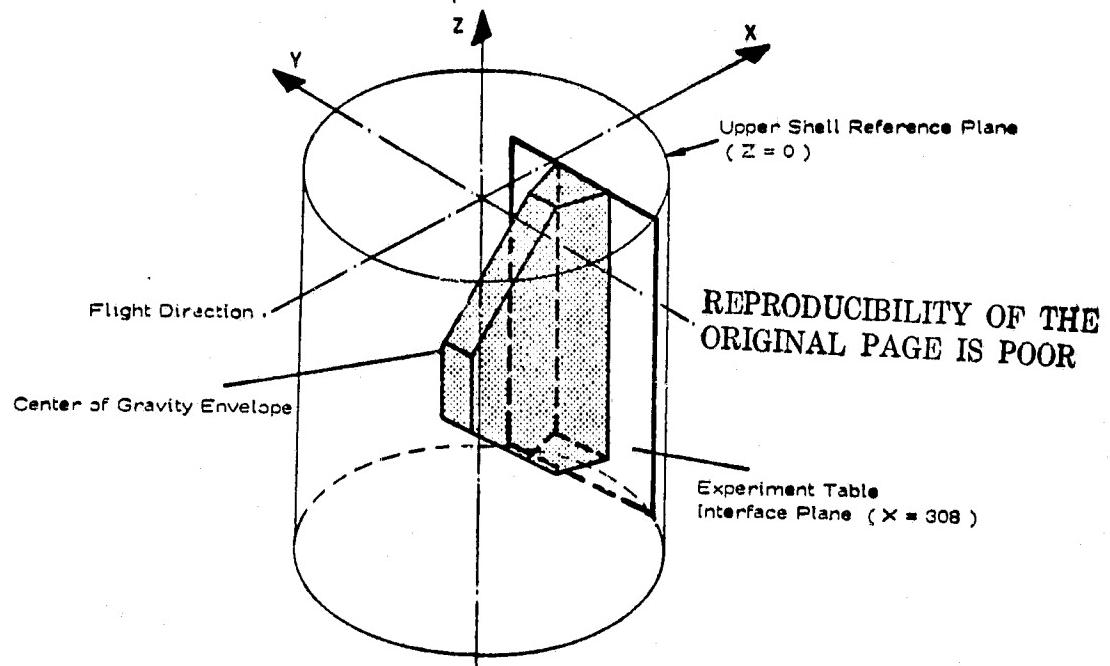


Figure 3.6 - 10 : Experiment Payload Center of Gravity Envelope (3 Dimensional)

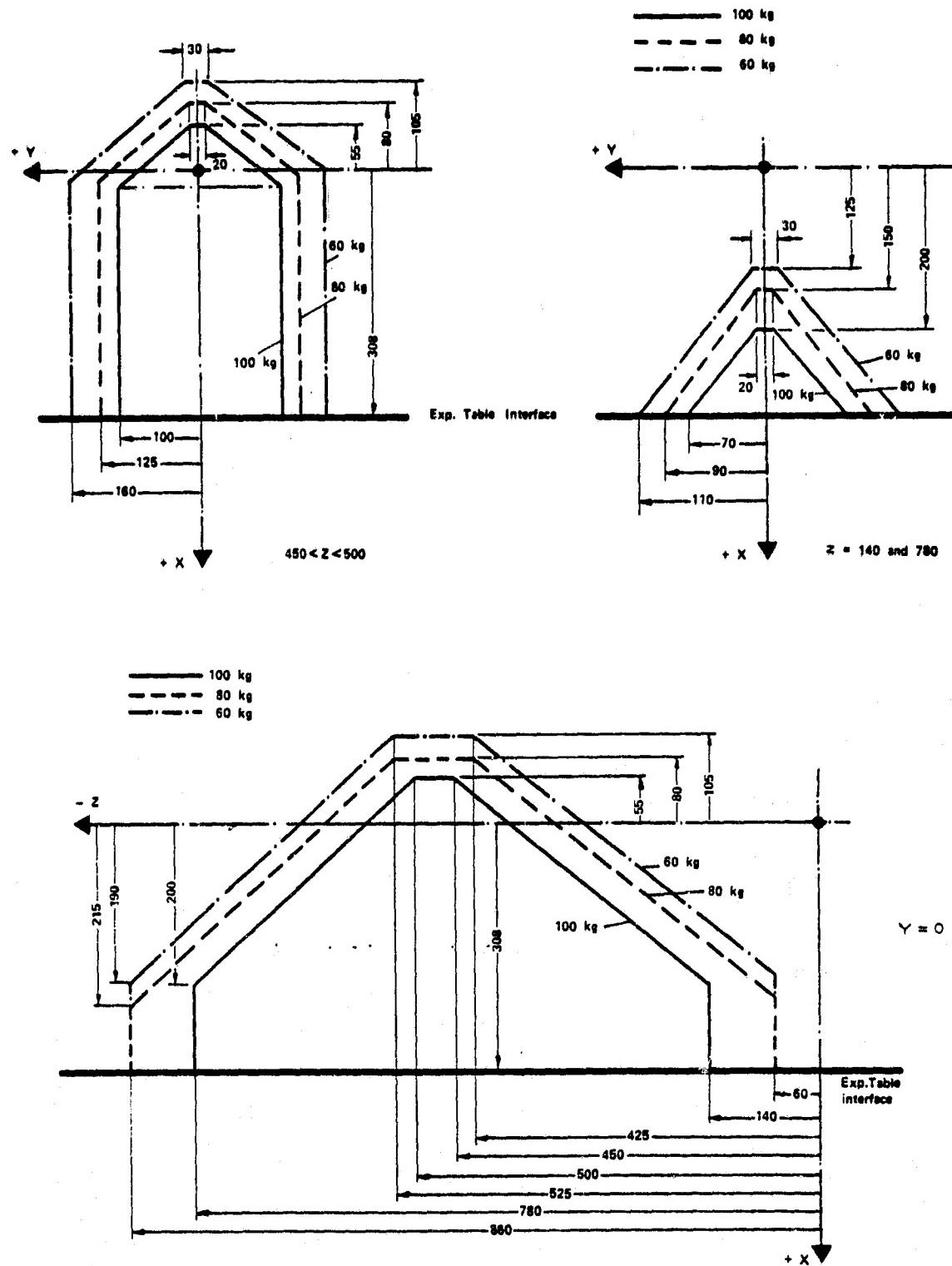


Figure 3.6 - 11: Experiment Payload Center of Gravity

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3.6.1.9 Mechanical Environment

The mechanical environment is given in Table 3.6 - 3.

Table 3.6 - 3 : Airlock Mechanical Environment.

TBD

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3.6.2 Viewport Assembly

The viewport assembly basically is a 30 cm diameter window with inner and outer cover as shown in Figure 3.6 - 12. Three identical units are used in Spacelab;

- o A viewport assembly is permanently installed in the aft end cone as basic Spacelab equipment (aft viewport).
- o A viewport assembly is included in the CPSE Viewport Adaptor Assembly
- o A viewport assembly is included in the CPSI High Quality Window/Viewport Assembly.

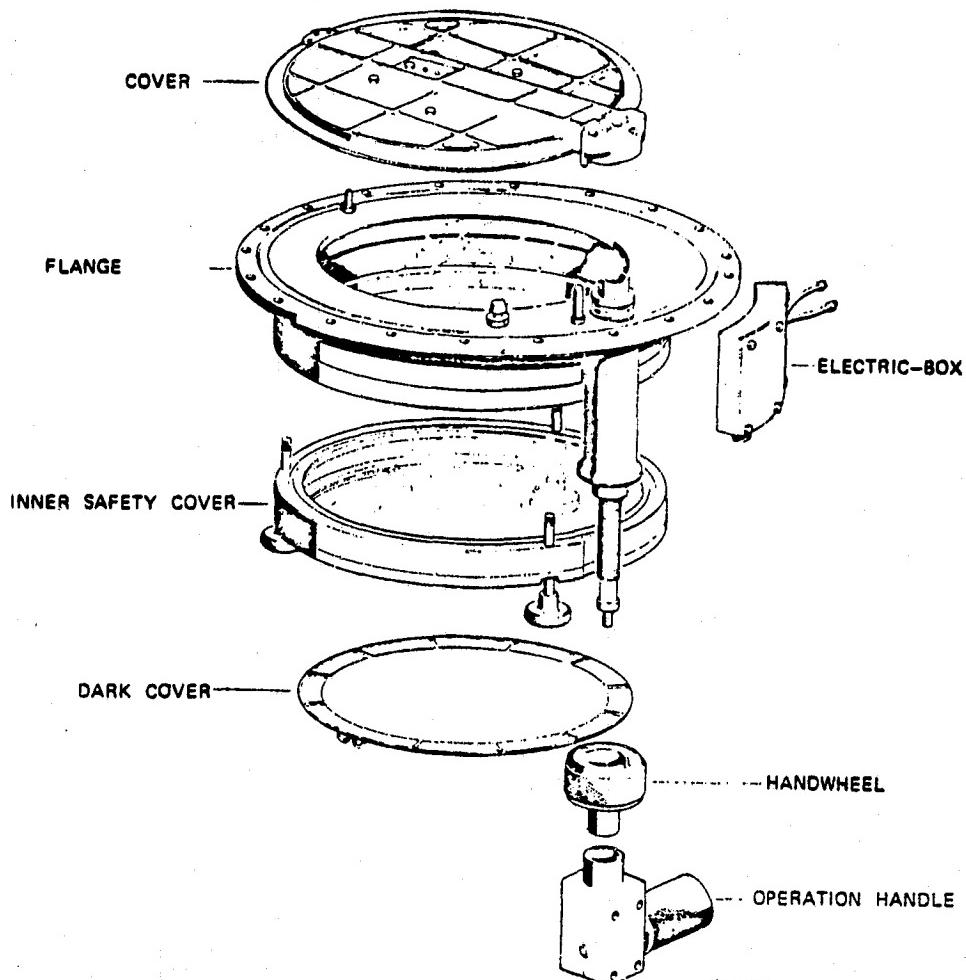


Figure 3.6 - 12: Viewport Assembly - Exploded View

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3.6.2.1 Payload Attachment Interface

If the inner safety cover is removed experiment equipment can be mounted to the viewport assembly using the three safety cover attachment points on the viewport flange. Location and details of these safety cover / experiment attachment points is shown in Figure 3.6 - 13.

3.6.2.2 Load Carrying Capability

The maximum allowable experiment mass that can be attached to the viewport assembly is :

On Orbit	:	25 kg
Ascent/Descent	:	0 kg
Emergency Landing:	:	25 kg
C.g. envelope	:	TBD

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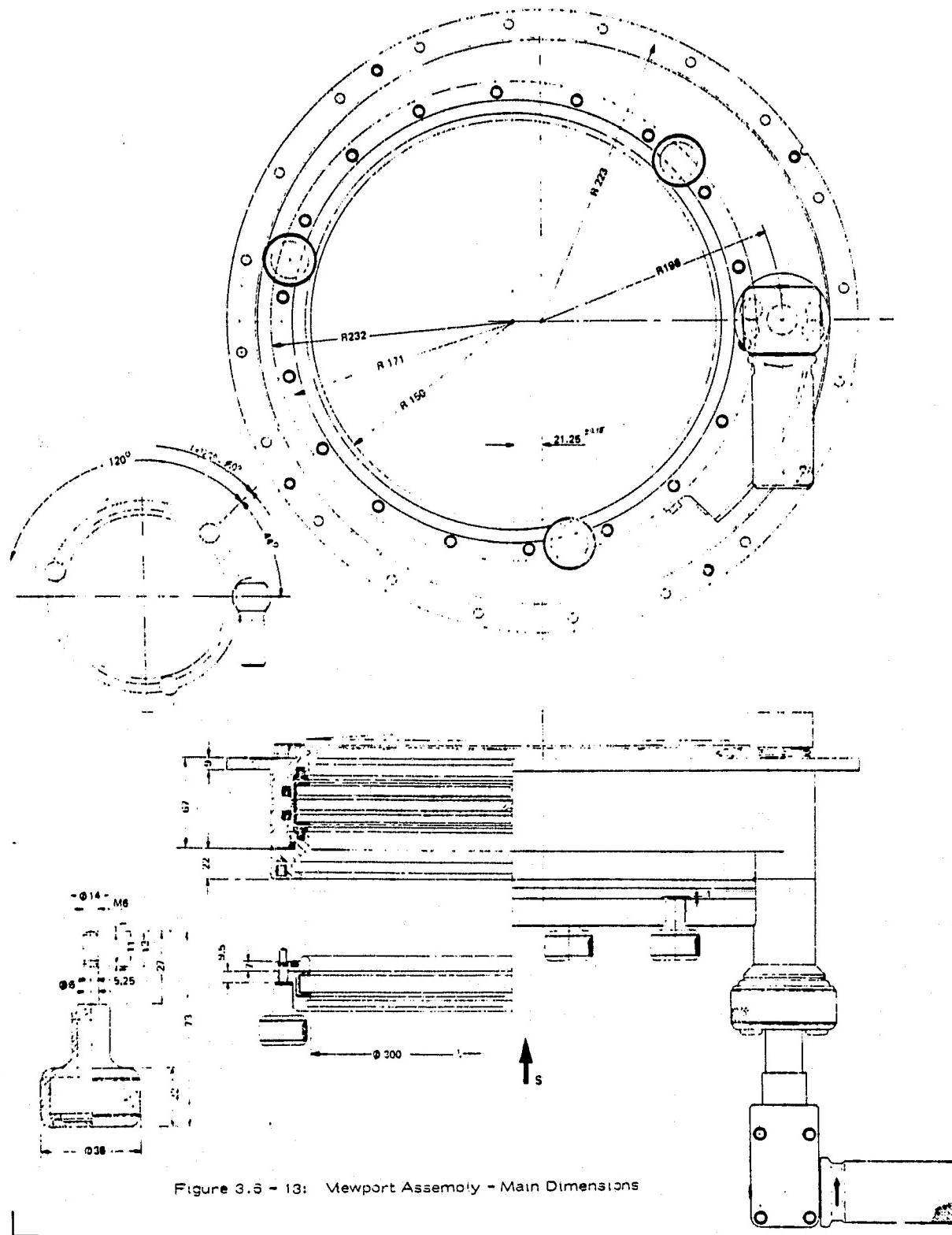


Figure 3.6 - 13: Newport Assembly - Main Dimensions

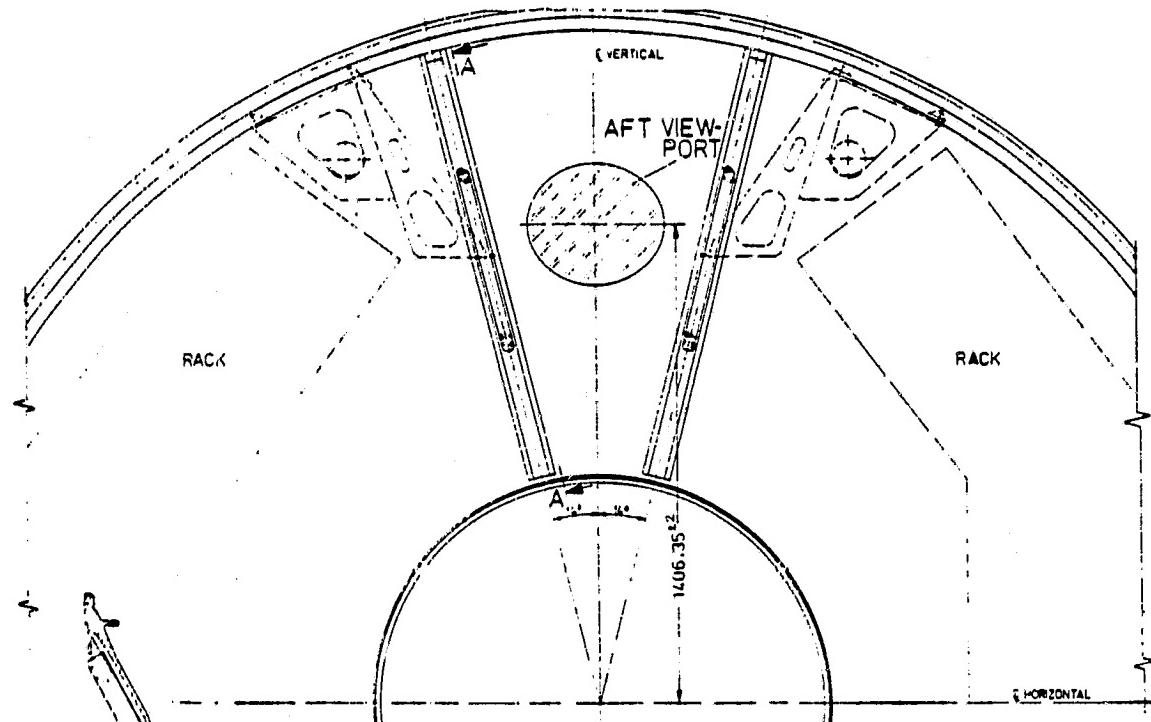
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3.6.3 Aft Viewport

The location of the viewport assembly at the aft end cone is shown in Figure 3.6 - 14 and 15. Also shown are the handrails adjacent to the aft viewport which may serve for experiment attachment.



SECTION A-A

SECTION B-B

SECTION C-C

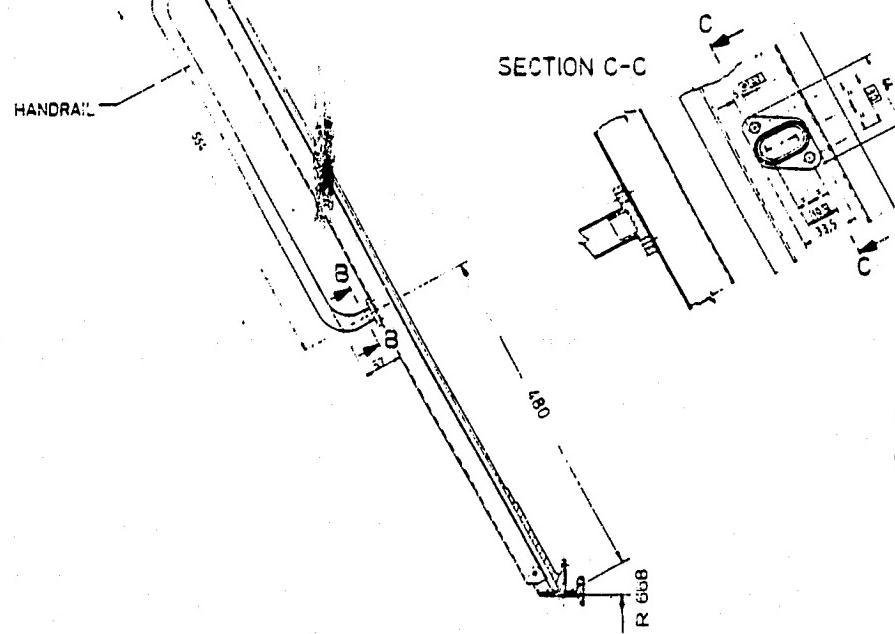


Figure 3.6 - 14.: Aft Viewport - Location Geometry

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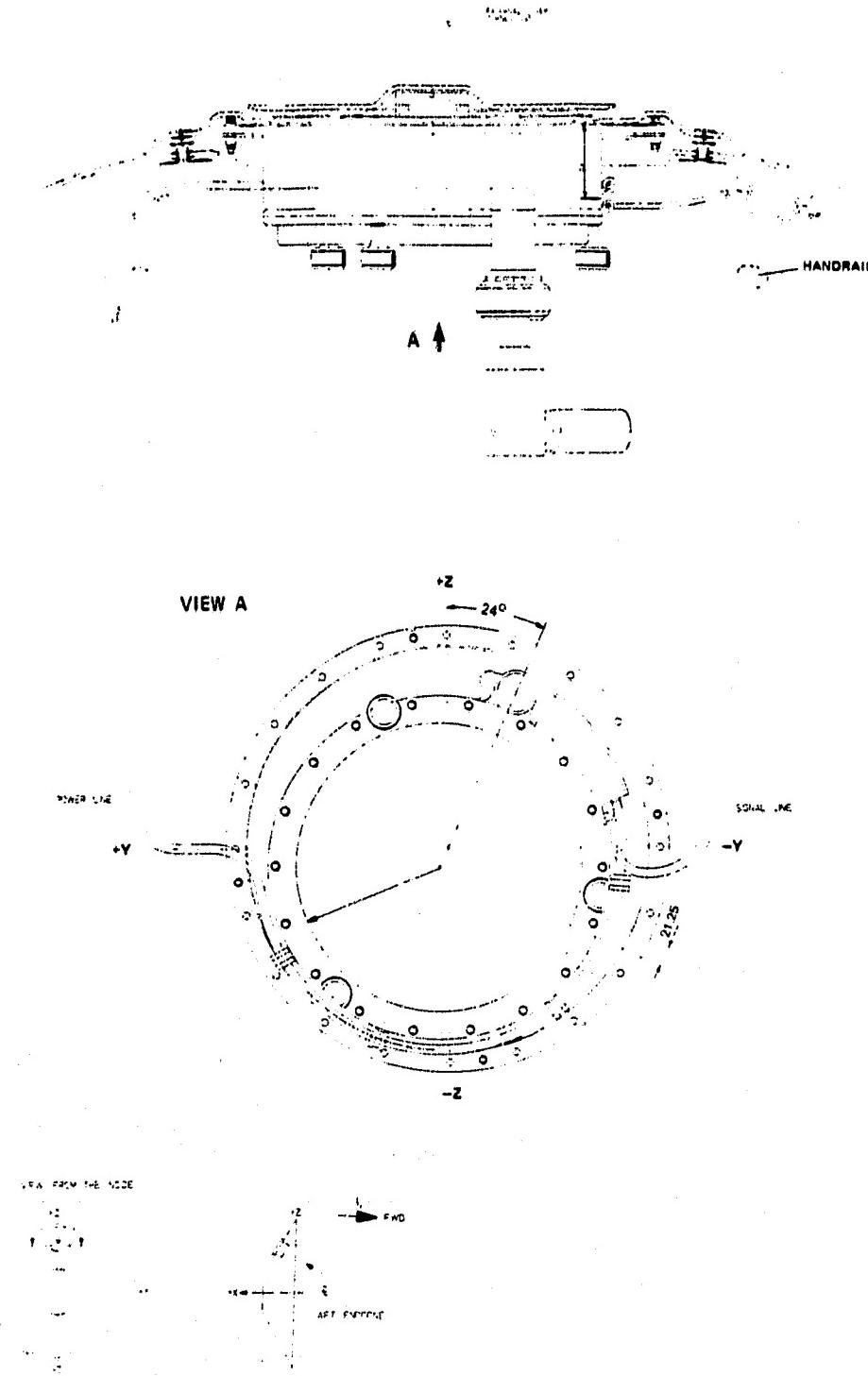
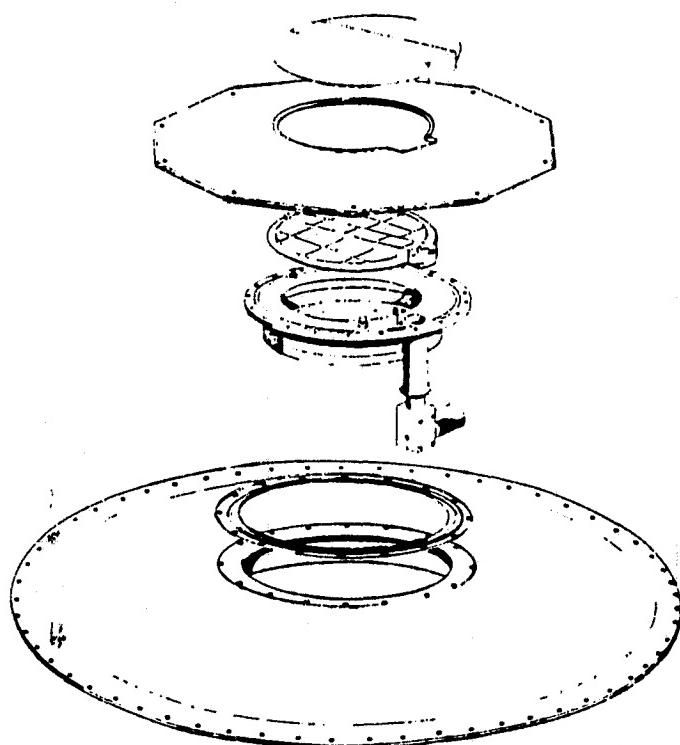


Figure 3.6 - 15 : Aft Viewport Location

3.6.4

Viewport Adapter Assembly

As shown in Figure 3.6 - 16 the viewport adapter assembly combines the viewport assembly with an adapter plate which allows mounting to the module 1.3 m top openings.



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Figure 3.6 - 16 : Viewport Adapter Assembly

The main dimensions of the Viewport Adapter Assembly are shown in Figures 3.6 - 17 and 18.

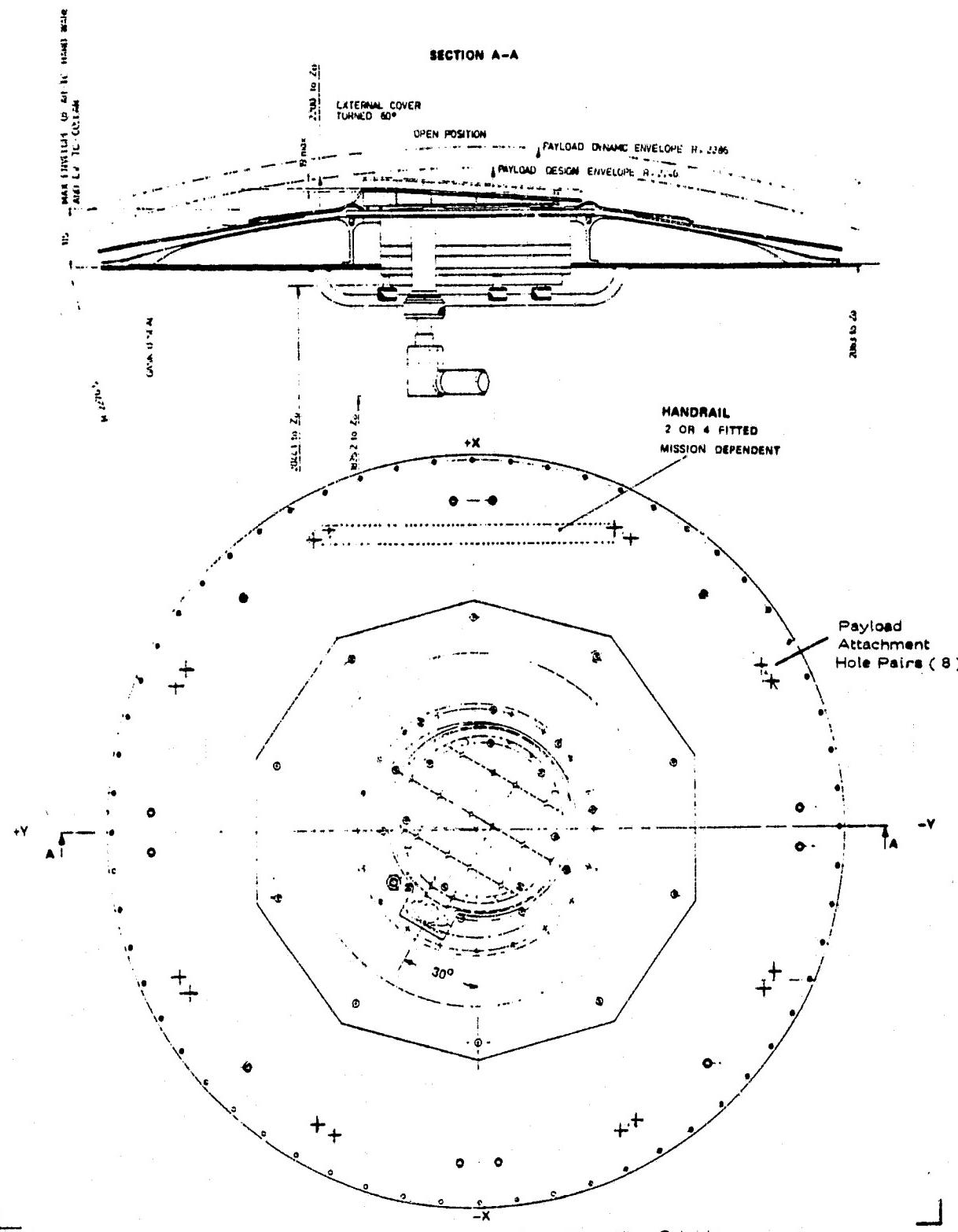


Figure 3.6 - 17: Viewport Adapter Assembly - View Outside

SECTION A - A

SECTION B - B

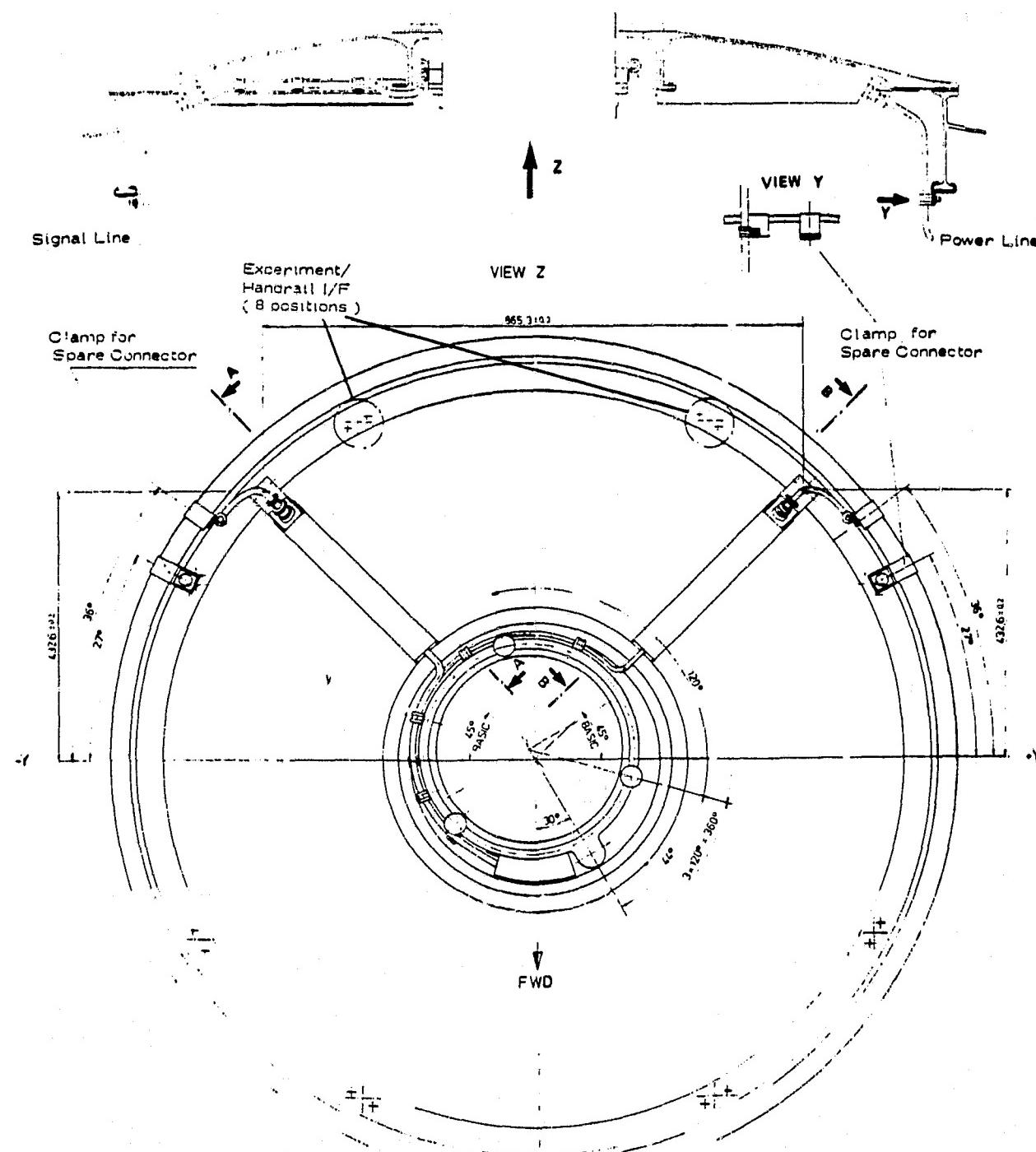


Figure 3.6 - 18: Viewport Adapter Assembly-View Inside

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3.6.4.1 Payload Attachment Interface

There are 8 identical hole pairs on the rear of the adapter plate for attachment of hand rails and/or experiment equipment as shown in Figure 3.6 - 19. The handrails can be mounted alternatively in X or Y direction according to experiment requirements.

3.6.4.2 Load Carrying Capability

If nothing is mounted to the viewport assembly itself the maximum allowable experiment mass that can be attached to the adapter plate is :

On Orbit	:	50 kg
Ascent/Descent	:	0 kg
Emergency Landing	:	50 kg
C.g. envelope	:	TBD

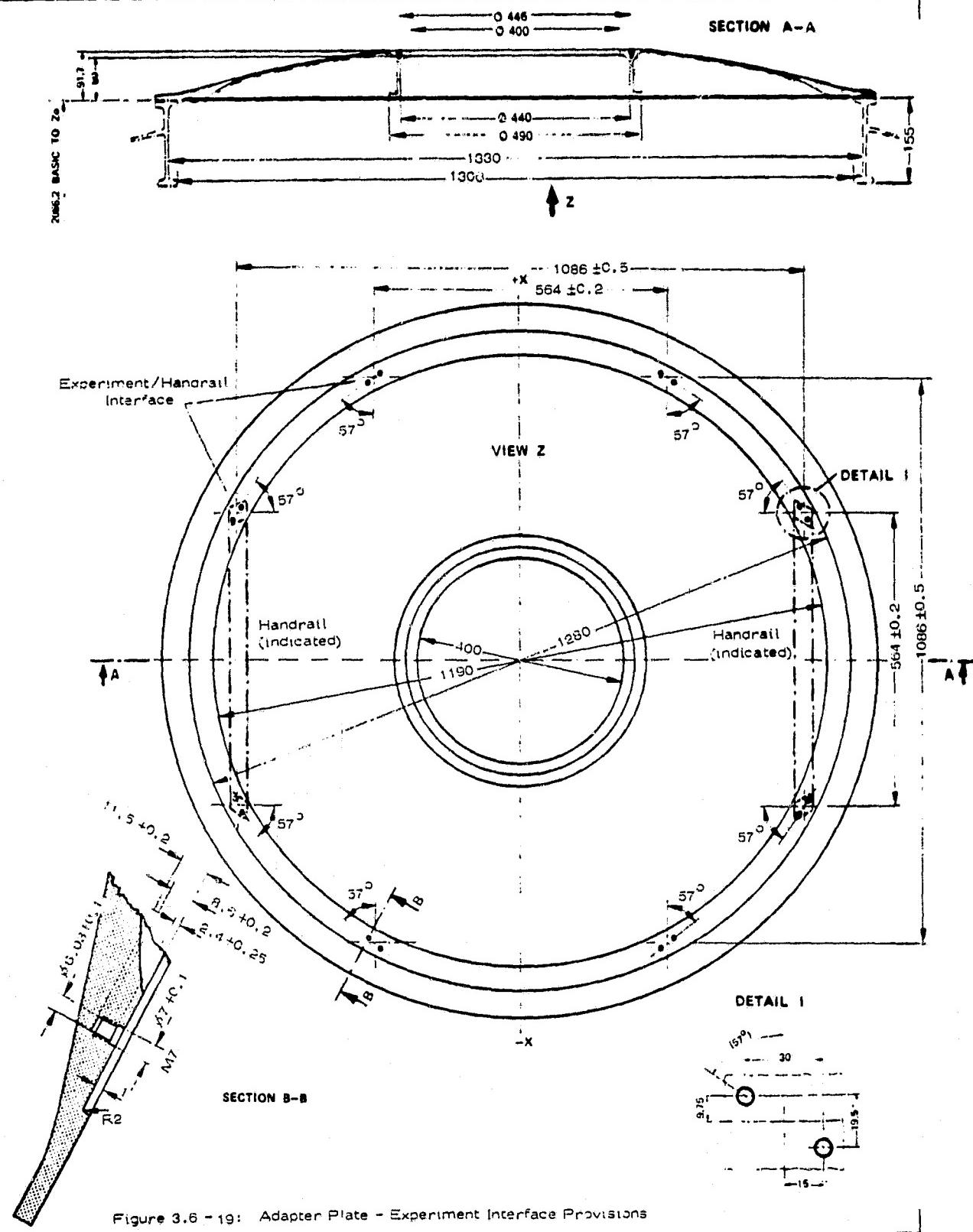


Figure 3.6 - 19: Adapter Plate - Experiment Interface Provisions

3.6.5 High Quality Window/Viewport Assembly

Details of the high quality window/viewport assembly are TBD.
A tentative view is given in Figure 3.6 - 20.

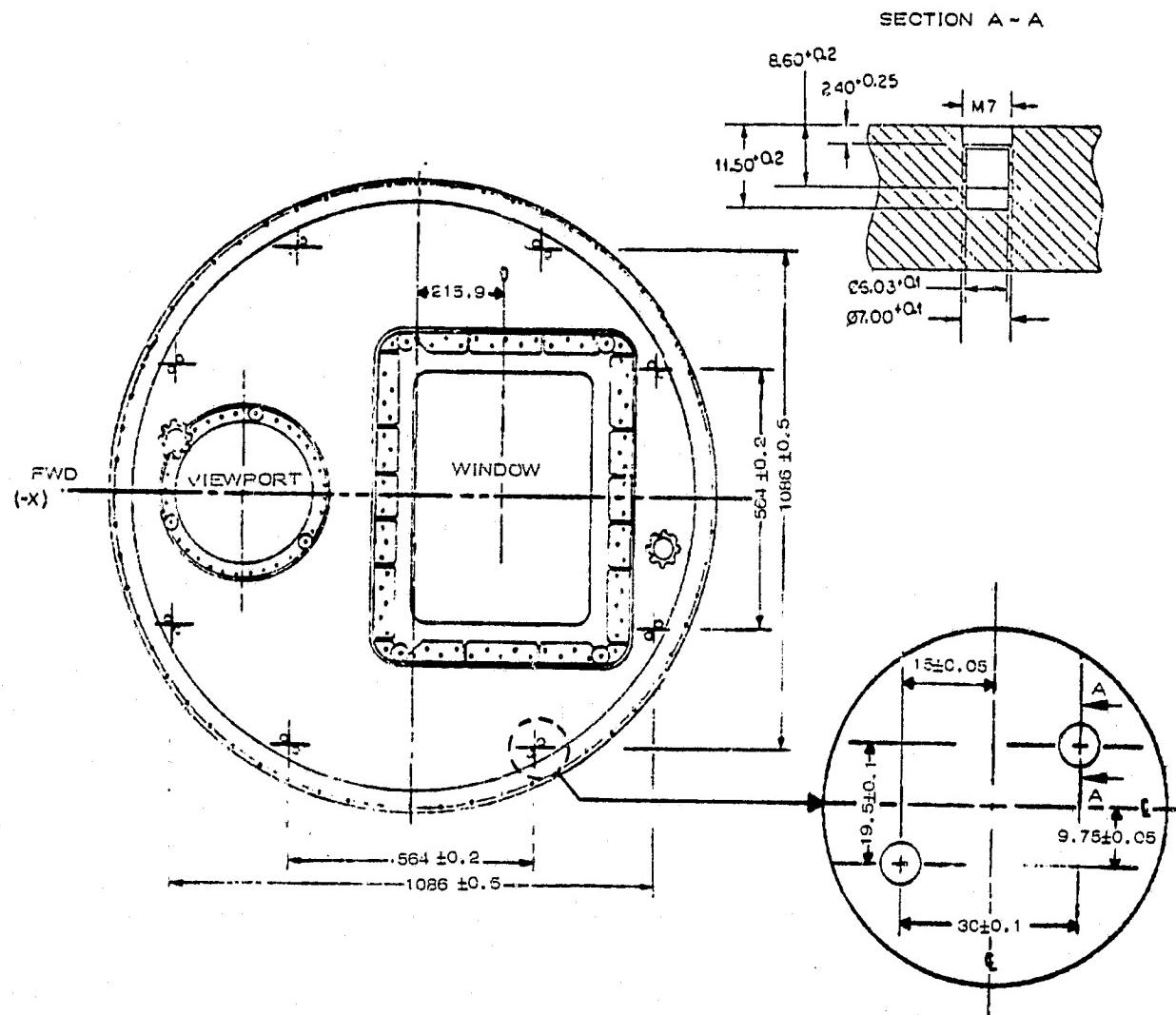


Figure 3.6 - 20: Tentative High Quality Window/Viewport Assembly Layout

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C-4

3.7. Experiment Vent Assembly

The purpose of the experiment vent assembly is to provide Spacelab users with the capability to evacuate specific experiment chambers. The manual vent valve includes selective flow restriction to control chamber decompression rates by placing the built-in butterfly valve into precalibrated and fixed positions between closed and full open.

The vent assembly has the male part of a quick disconnect in the cabin. The female coupling of the quick disconnect Type - CARLETON CONTROLS INTERNATIONAL, Experiment Vent Assembly, drawing number P/N 2810-0000 as well as flexible and rigid vacuum line routing to the experiment chamber, mounting substructures etc., are to be supplied by the user.

Figure 3.7 - 1 shows the location of the upper forward end cone feedthrough, Figure 3.7 - 2 gives the layout of the upper forward feedthrough and Figure 3.7 - 3 shows the interface between vent and feedthrough. Details of the vent assembly are given in Figure 3.7 - 4.

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B) UPPER FEEDTHROUGH

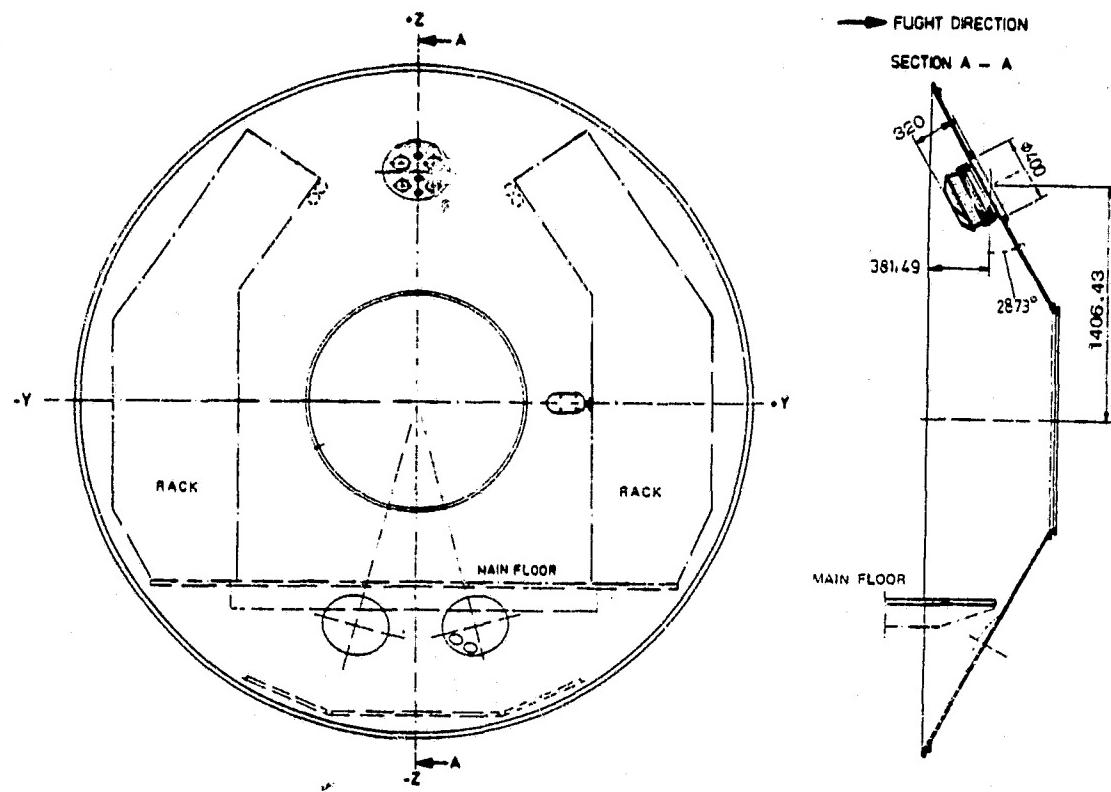
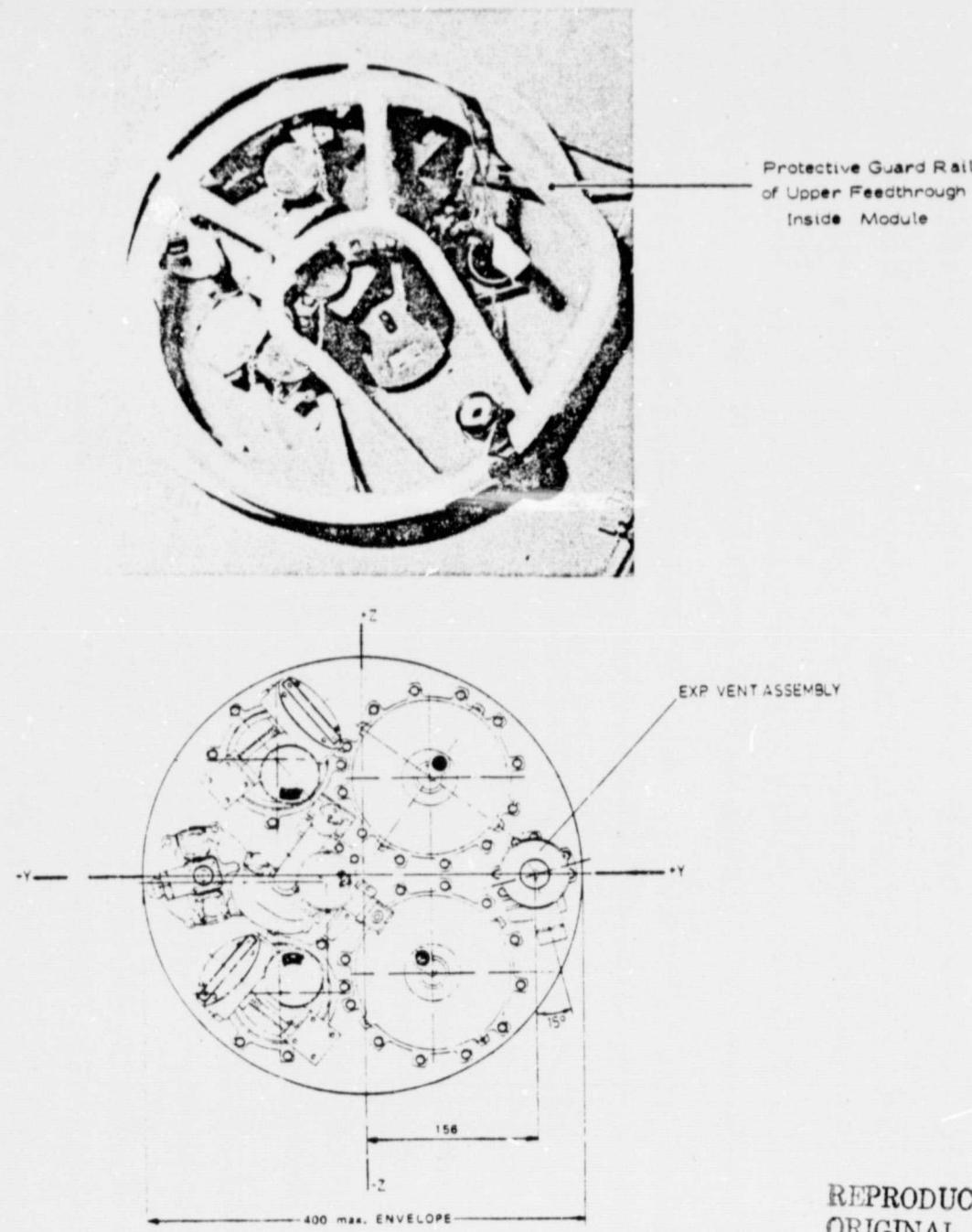


Figure 3.7 - 11 Location of Experiment Vent Assembly in the Module



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Figure 3.7 - 2: Layout of Forward Upper Feedthroughplate

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Figure 3.7 - 3 : Interface between Vent and Feedthrough

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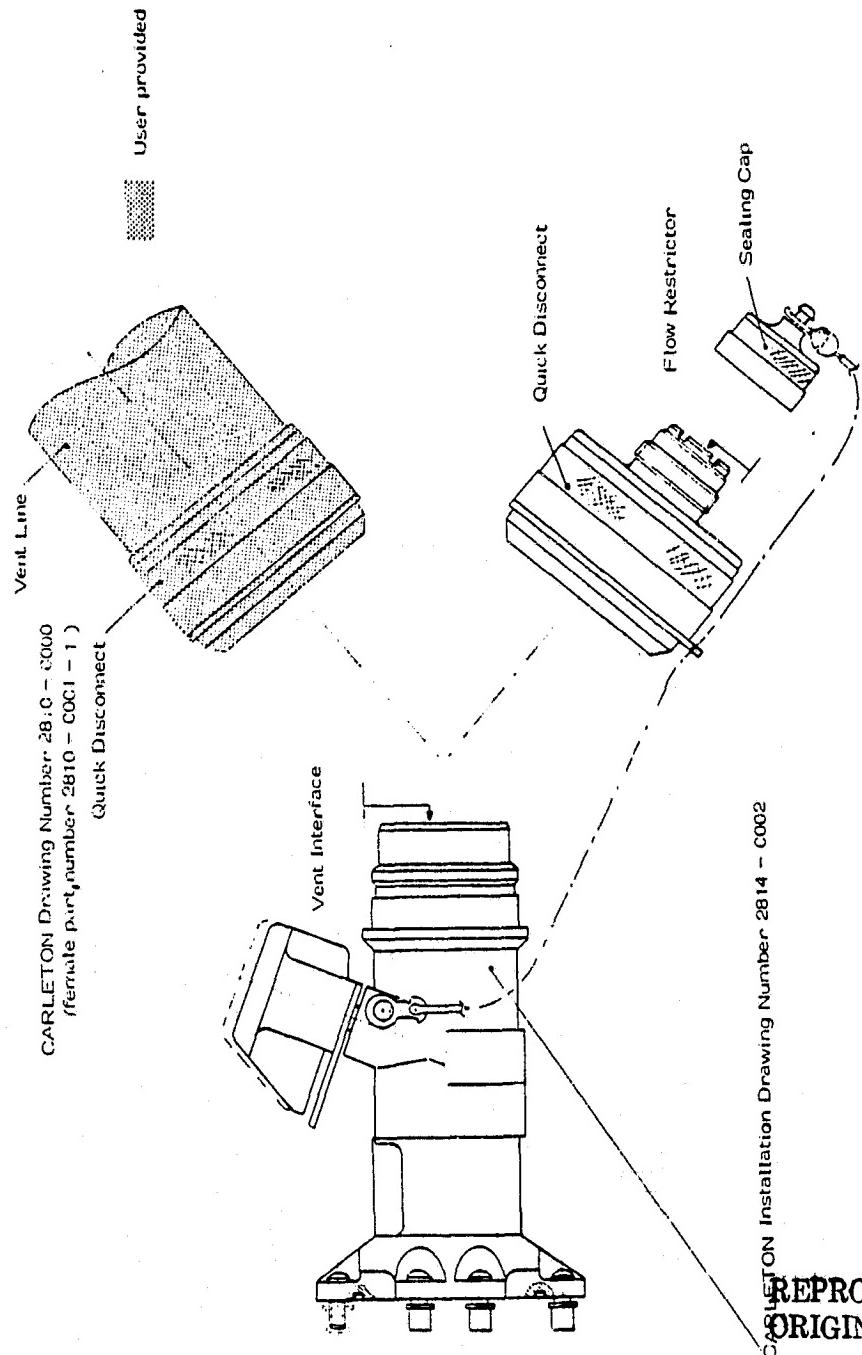


Figure 3.7 - 4: Details of Experiment Vent Assembly [Exploded View]

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3.8 Module Connector Brackets

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An overview of the connector brackets which are totally or partly experiment dedicated is given in Figure 3.8 - 1. For electrical characteristics reference is made to the corresponding sections of Appendix A. The connector brackets which are at standard experiment locations are described in the corresponding sections of this appendix (e.g. rack, center aisle, airlock). The connector brackets which can be described on a module system level are given below. These are

- the signal connector brackets CB 50 and CB 5 which provide the interface to Spacelab subsystems
- the essential power connector brackets CB 6, CB 16 and CB 28 which provide the interface to the experiment essential power bus
- the CPSE connector brackets CB 18, CB 25 and CB 26. These connector brackets provide a power interface if no common payload support equipment (CPSE) is installed (CB 18 and CB 26) or a signal interface to experiment equipment located in the CPSE airlock (CB 25).

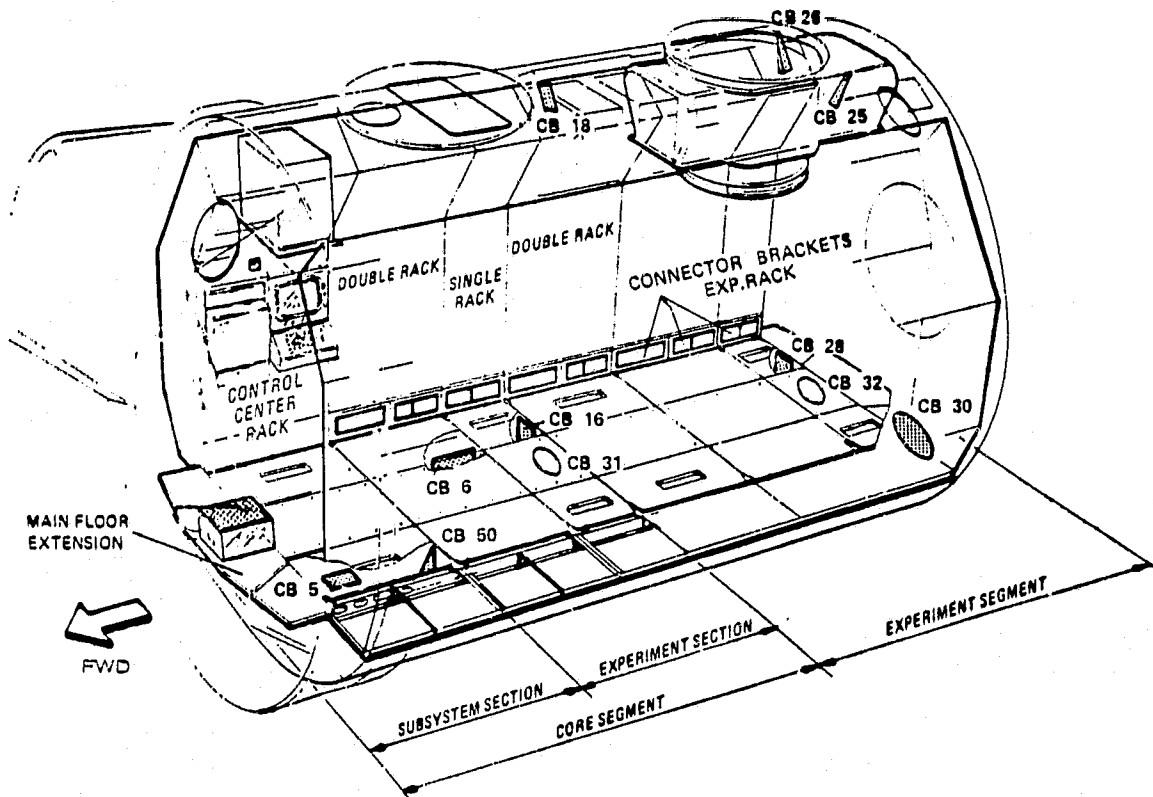


Figure 3.8 - 1 Location of Experiment Dedicated Connector Brackets in the Module

3.8.1 Signal Connector Brackets

3.8.1.1 Connector Bracket CB 50

Figure 3.8 - 2a shows the location of CB 50 in the mainfloor. The vicinity of CB 50 and the attachment to the mainfloor is depicted in Figure 3.8 - 2c while Figure 3.8 - 2b gives the detailed panel lay-out. For functional description see section 4.2.1 of Appendix A.

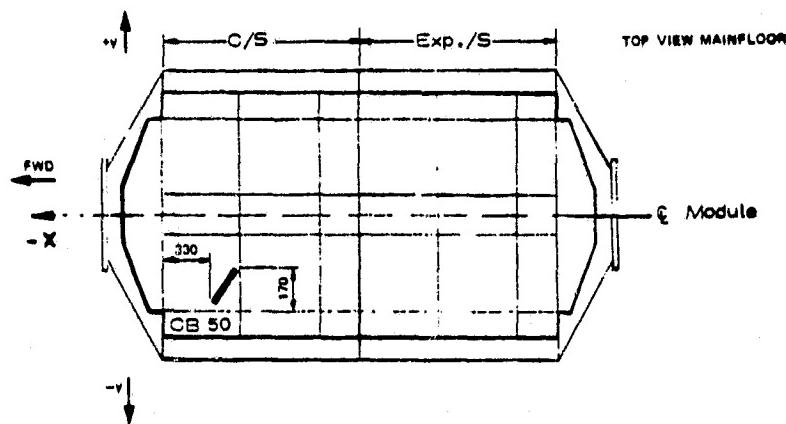


Figure 3.8-2a : Location of CB 50 in the Mainfloor

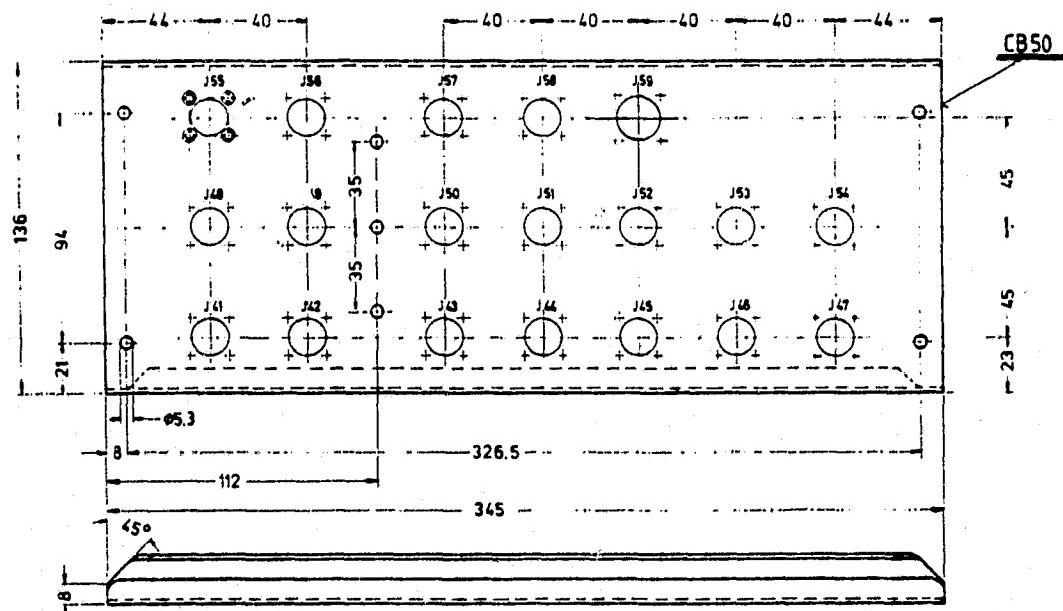
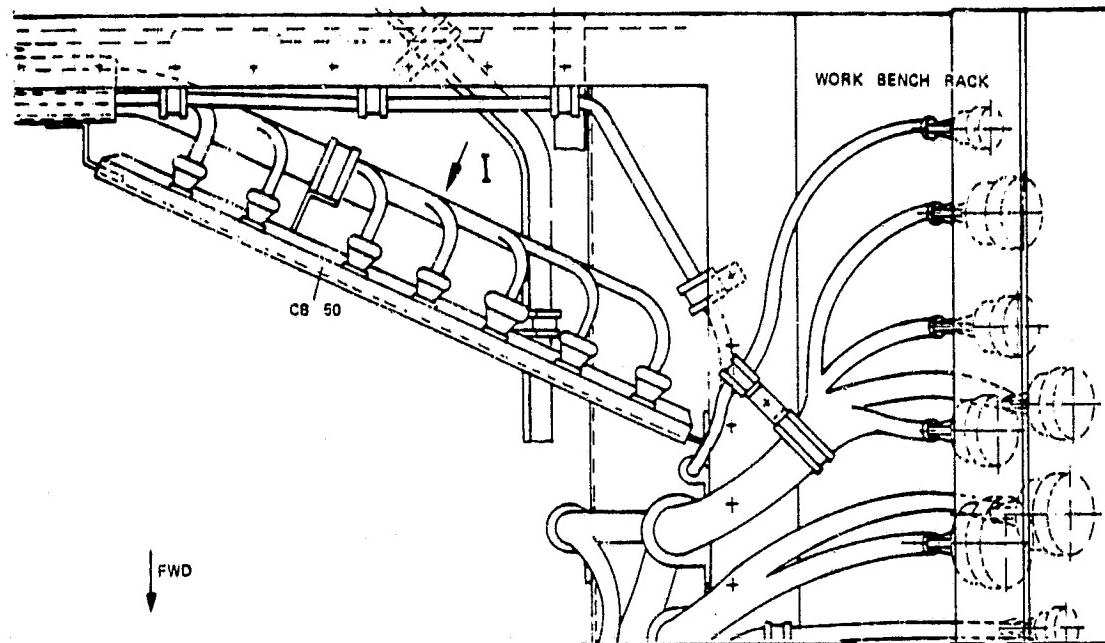


Figure 3.8-2b : Panel Lay - Out of CB 50

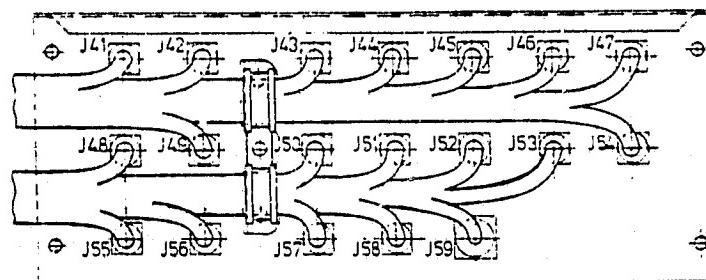
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Figure 3.8 - 2c : Vicinity of CB 50

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The view in y-z plane and the link to the experiment utility routings will be supplied
in a later issue.

Figure 3.8 - 2d : Vicinity of CB 50

3.8.1.2 Connector Bracket CB 5

Figure 3.8 - 3a shows the location of CB 5 on the subfloor of the core segment. The vicinity of CB 5 and the attachment to the subfloor panel are depicted in Figure 3.8 - 3c while Figure 3.8 - 3b gives the detailed panel lay-out. For functional description see section 5.3.1 of Appendix A.

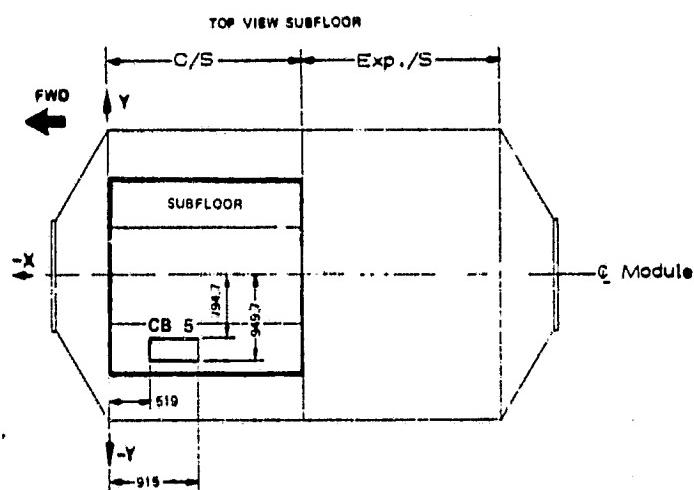
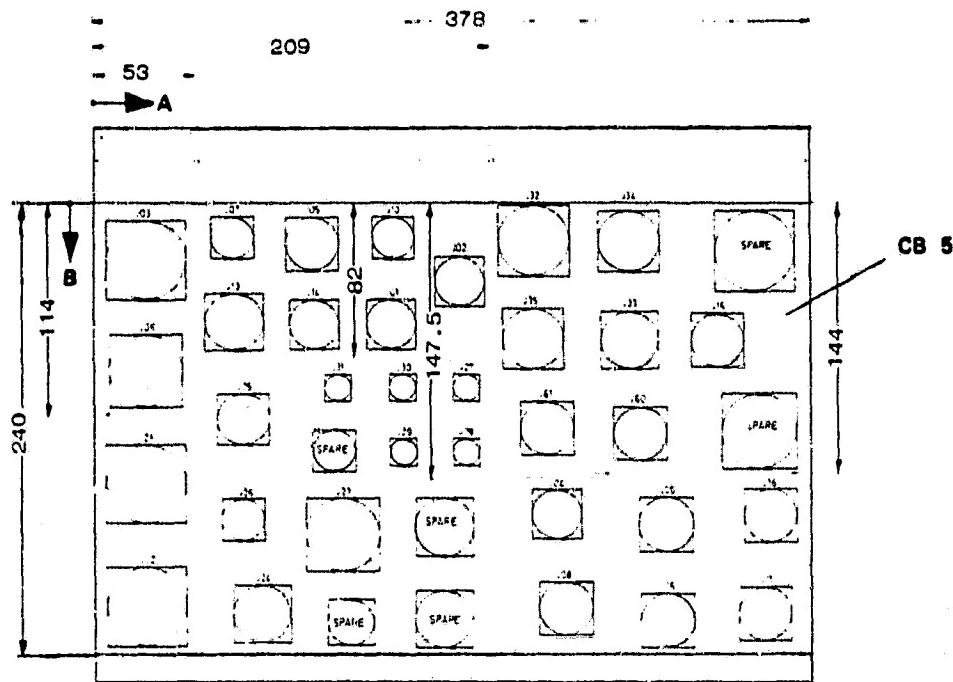


Figure 3.8 - 3a Location of CB 5 on the Subfloor

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VIEW II (see Fig. 3.8 - 3c)



Center of connectors on CB 5 are given in coordinates A and B

	A	B
J 01	156	64
J 02	192	41
J 03	27	30
J 04	243	165
J 05	114	21
J 06	27	89
J 07	72	18
J 08	248	217
J 09	300	170
J 10	157	18
J 11	353	217
J 13	73	63
J 14	115	64.5
J 15	328	72
J 16	301	222
J 21	27.5	149
J 22	27.5	213

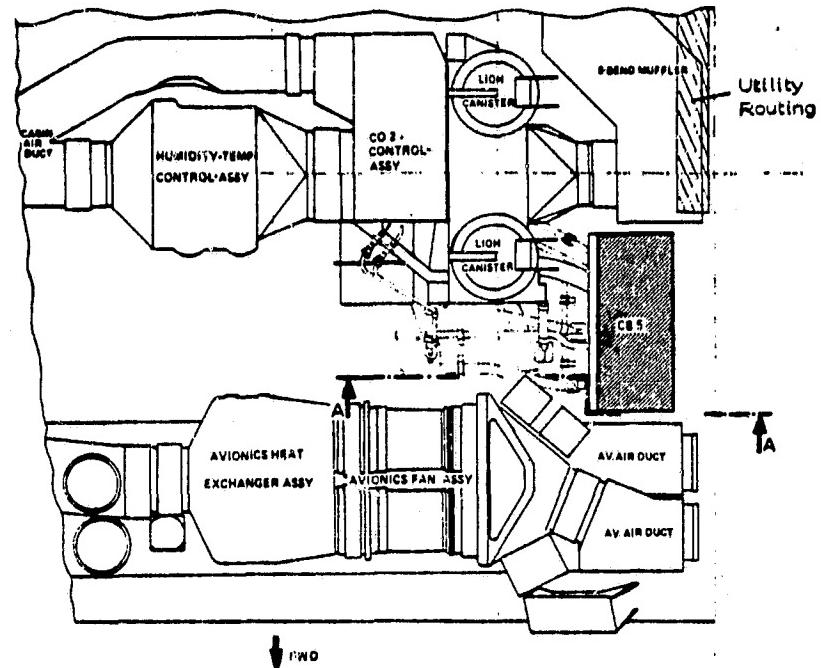
	A	B
J 23	130	176
J 24	87	218
J 25	78	115
J 26	78	168
J 27	195	98
J 28	195	132
J 29	162	122
J 30	162	98
J 31	127	98
J 32	231	20
J 33	281	72
J 34	281	21
J 35	231	71
J 36	356	165
J 60	287	122
J 61	238	119

Figure 3.8 - 3b Panel Lay-Out of CB 5

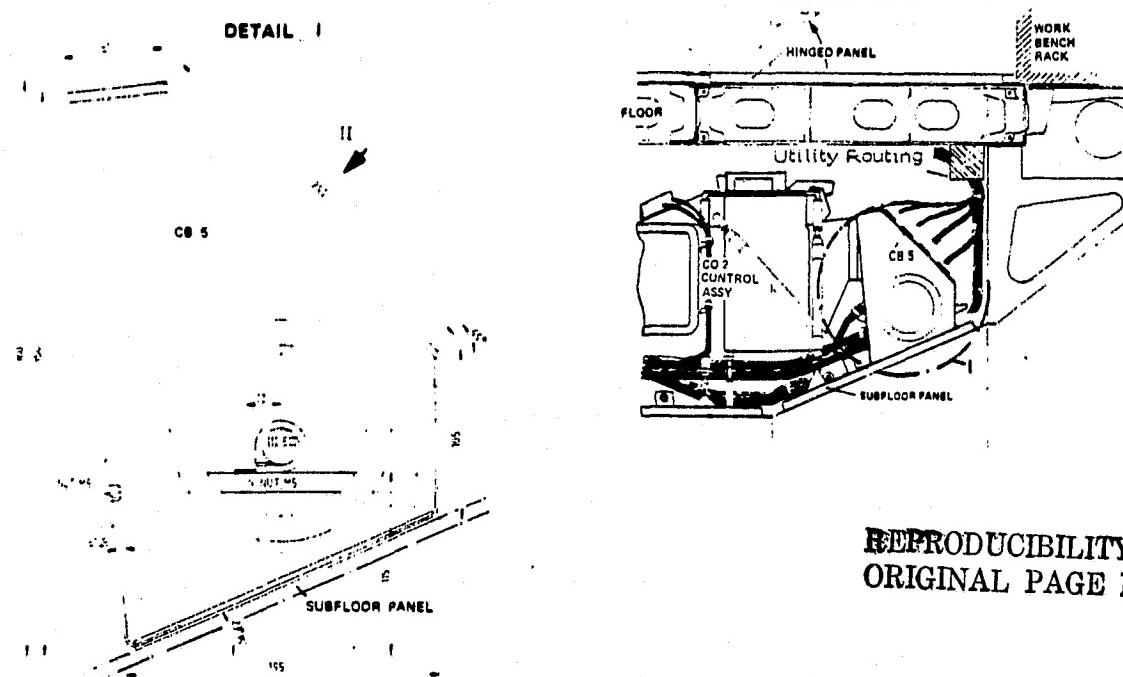
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DETAIL



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Figure 3.8 - 3c Vicinity of CB 5

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Further details as side view of section A - A and the link to the experiment utility routings will be supplied in a later issue.

Figure 3.8 - 3d : Vicinity of CB 5

3.8.2 Connector Brackets for Essential Power

3.8.2.1 Connector Bracket CB 6

The location of CB 6 in the mainfloor is depicted in Figure 3.8 - 4a. Figure 3.8 - 4c shows the vicinity of CB 6 and the attachment to the mainfloor while Figure 3.8 - 4b gives the detailed panel lay-out. For functional description see section 3.4 of Appendix A.

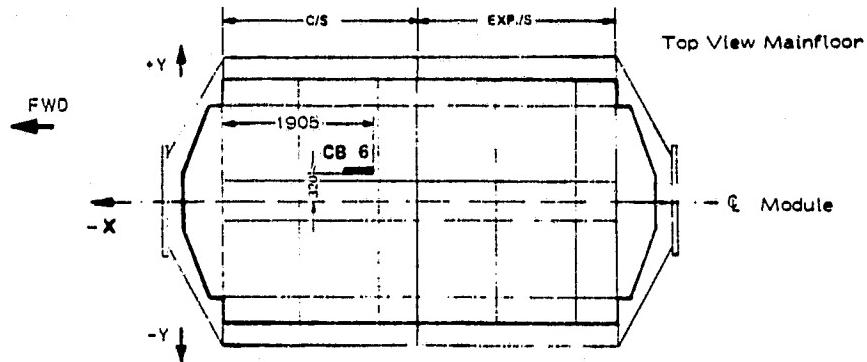


Figure 3.8 - 4a : Location of CB 6 in the Mainfloor

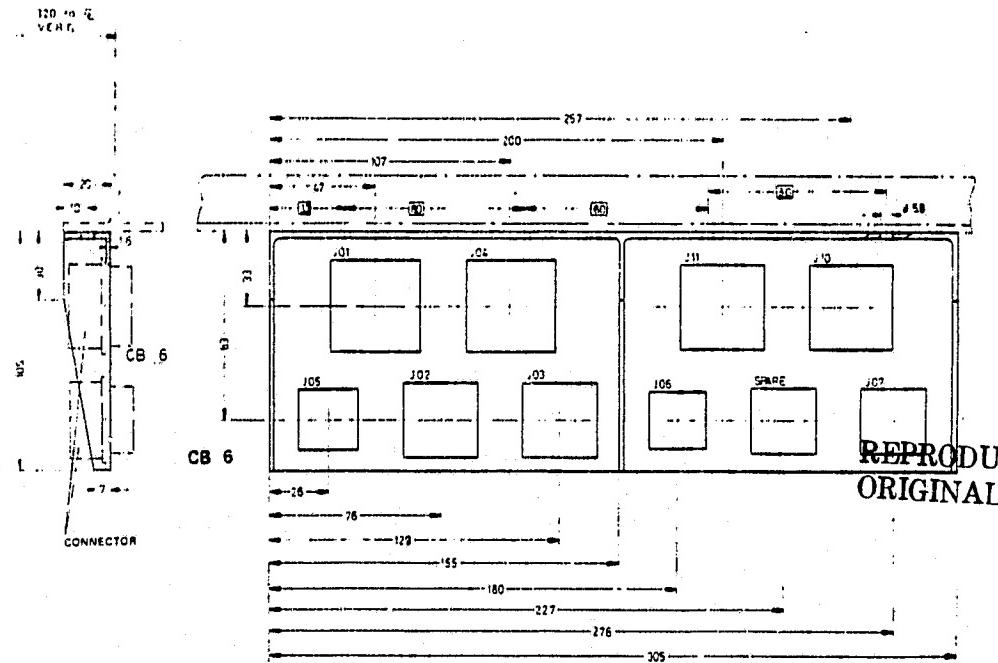


Figure 3.8 - 4b : Panel Lay-Out of CB 6

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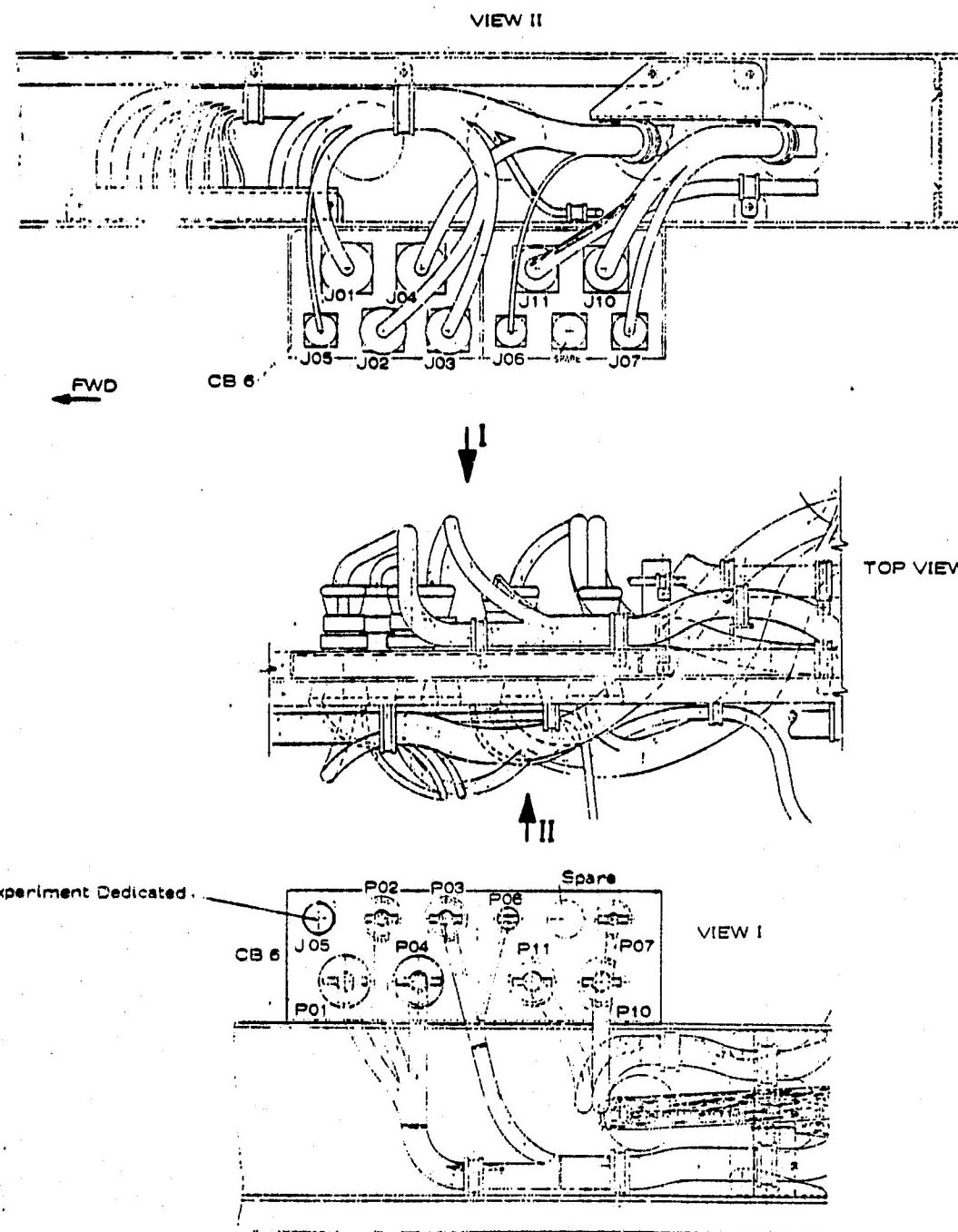


Figure 3.8 - 4c : Vicinity of CB 6

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The link to the experiment utility routings will be supplied in a later issue.

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Figure 3.8 - 4d : Vicinity of CB 6

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3.8.2.2 Connector Brackets CB 16 and CB 28

The connector brackets CB 16 and CB 28 are located in the mainfloor as depicted in Figure 3.8 - 5a. Both connector brackets are identical with respect to lay-out and attachment to the mainfloor. Therefore Figure 3.8 - 5c shows as an example the vicinity and the attachment of CB 16 while Figure 3.8 - 5b shows the detailed panel lay-out. For the connector notation of CB 28 see para. 3.4.1 of Appendix A.

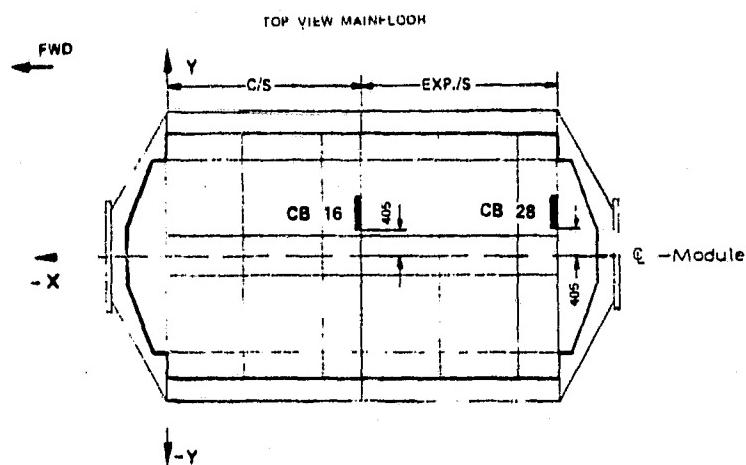


Figure 3.8 - 5a : Location of CB 16 and CB 28 in the Mainfloor

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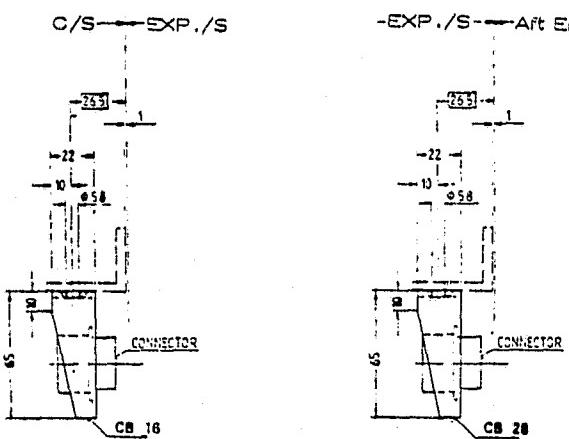
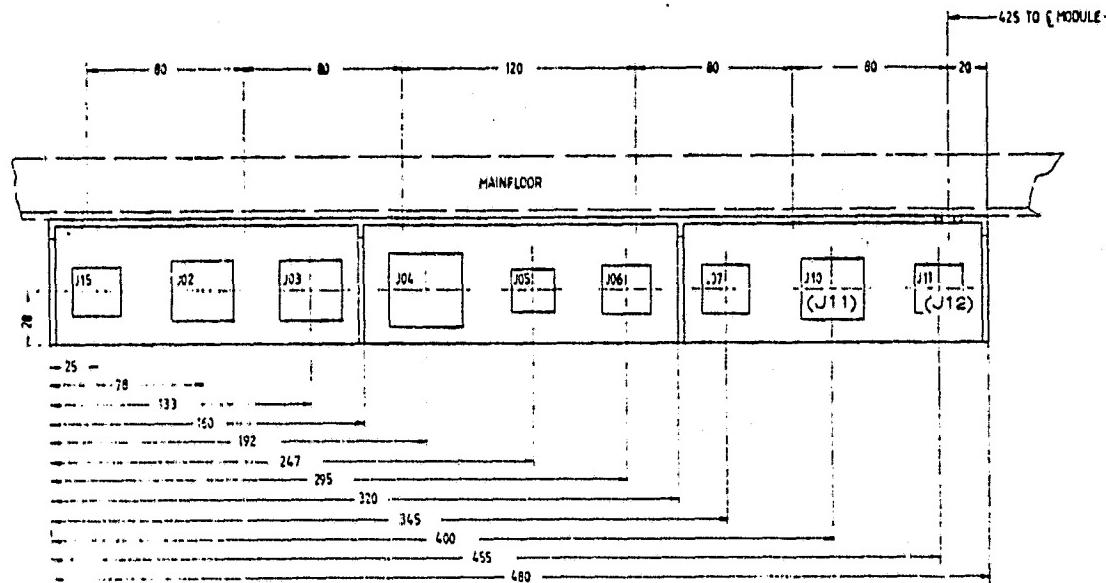


Figure 3.8 - 5b: Panel Lay - Out of CB 16 (CB 28)

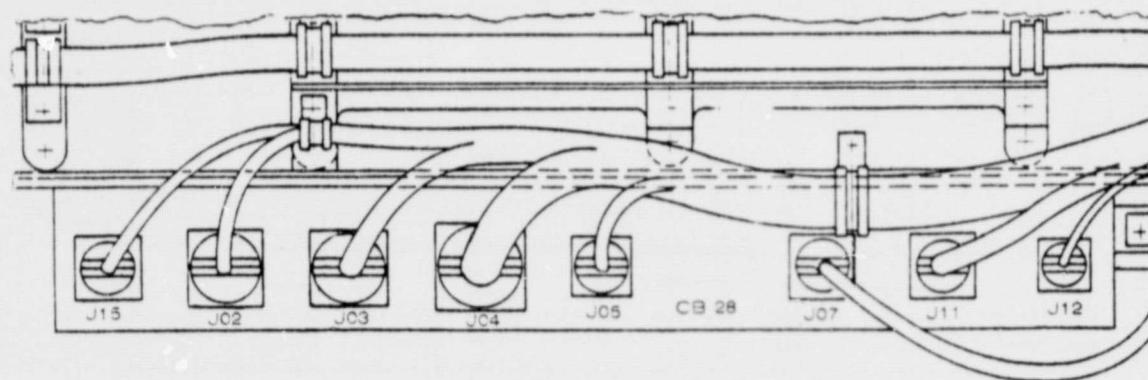
Note : For CB 28, same lay-out with connector numbers in parenthesis valid.

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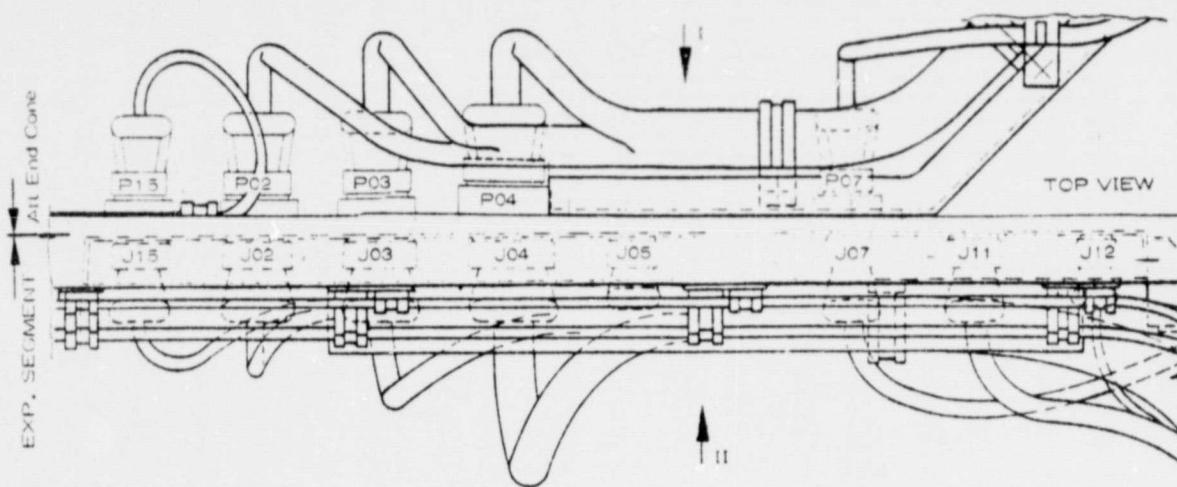
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VIEW II



TOP VIEW



Experiment dedicated

VIEW I

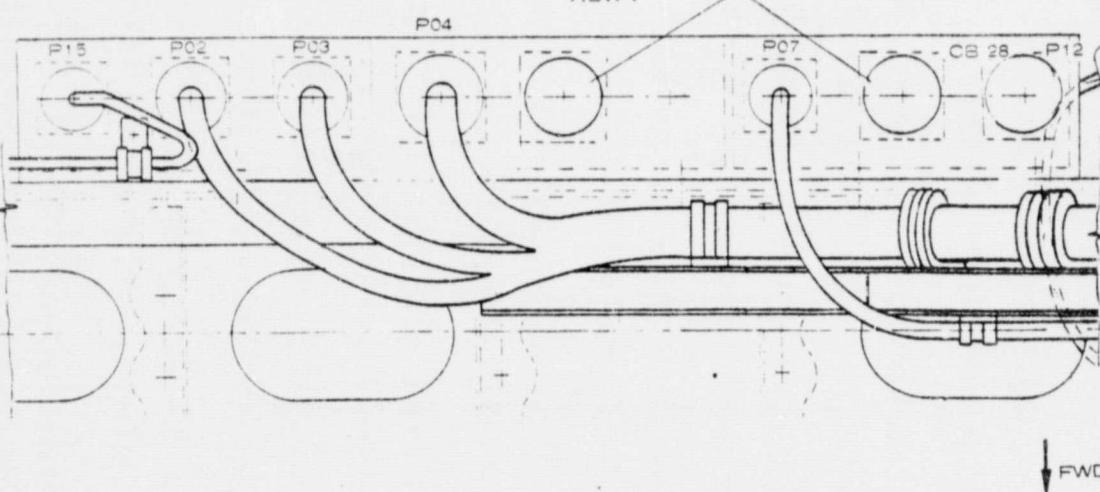


Figure 3.8 - 5c : Vicinity of CB 28

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The link to the experiment utility routings will be supplied in a later issue.

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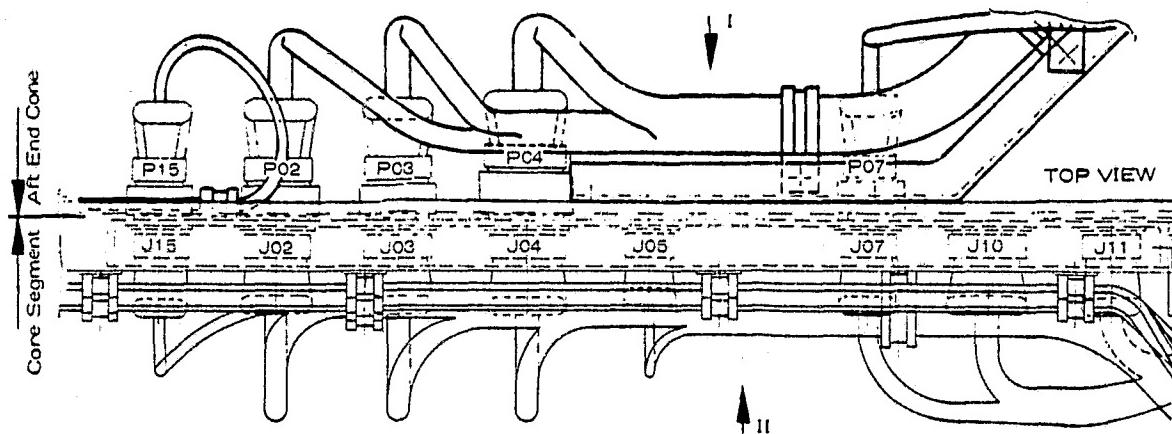
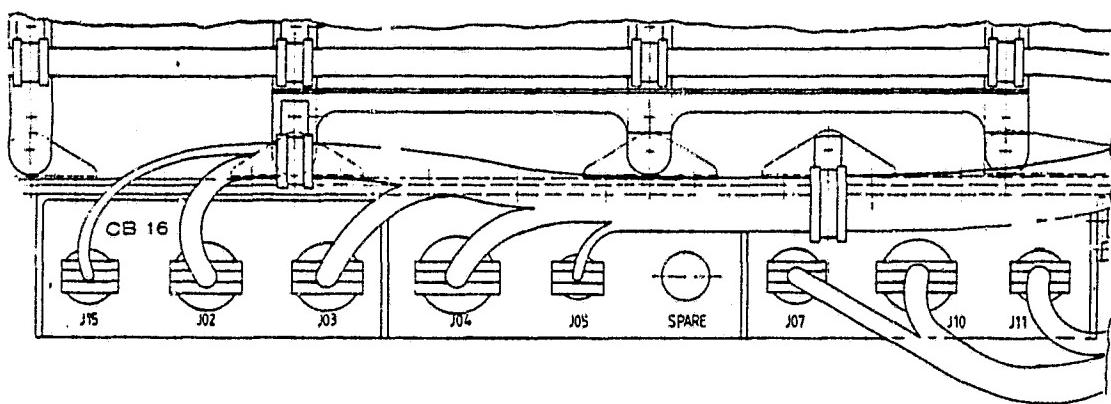
Figure 3.8-5c : Vicinity of CB 29

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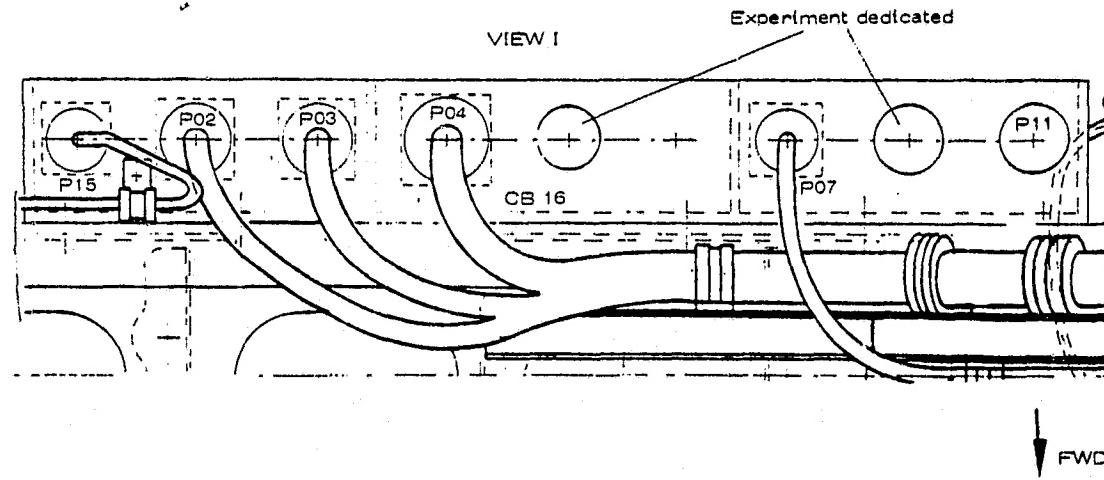


Figure 3.8-5d : Vicinity of CB 16

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Figure 3.8-5d : Vicinity of CB 16

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VIEW II

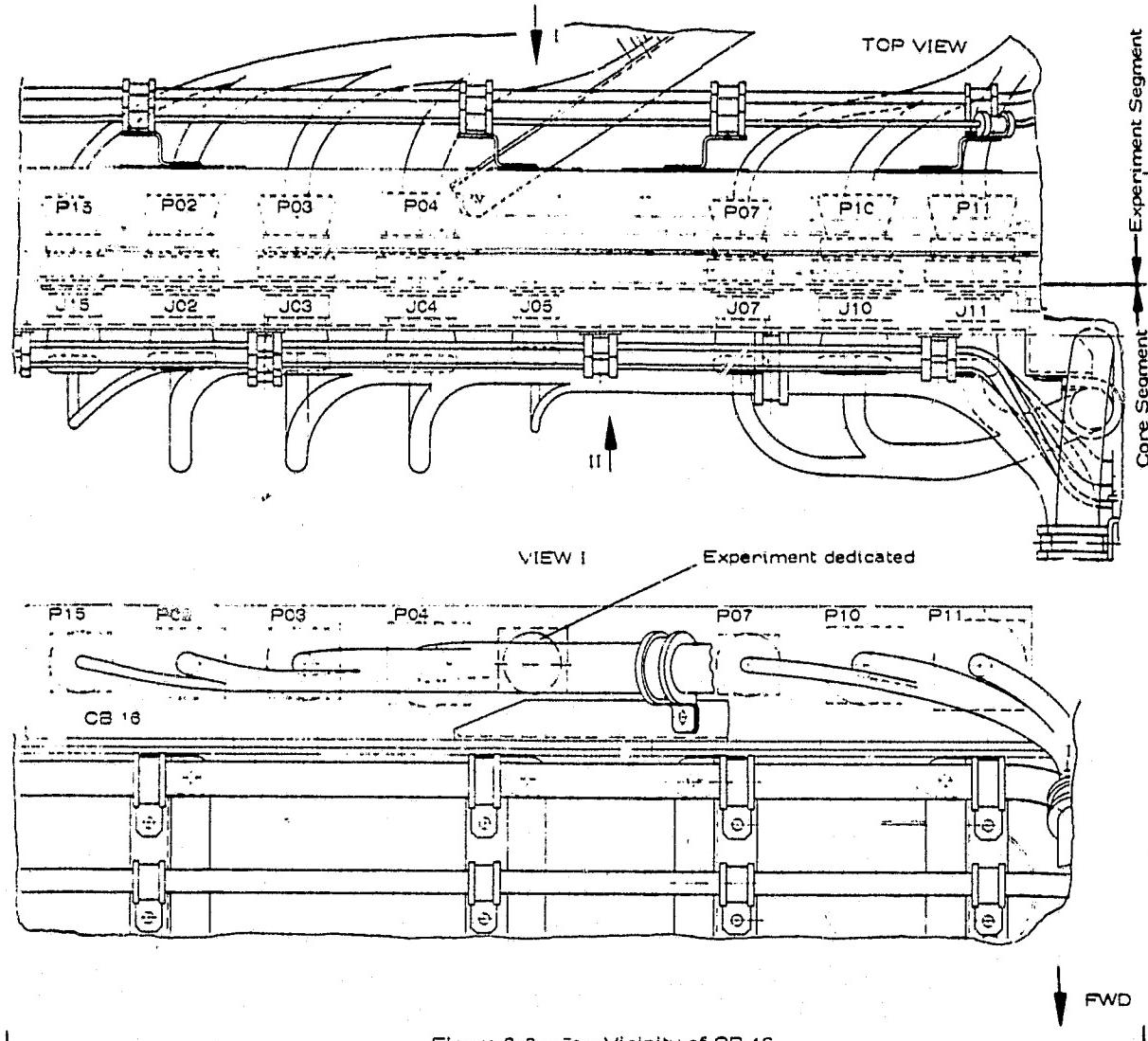
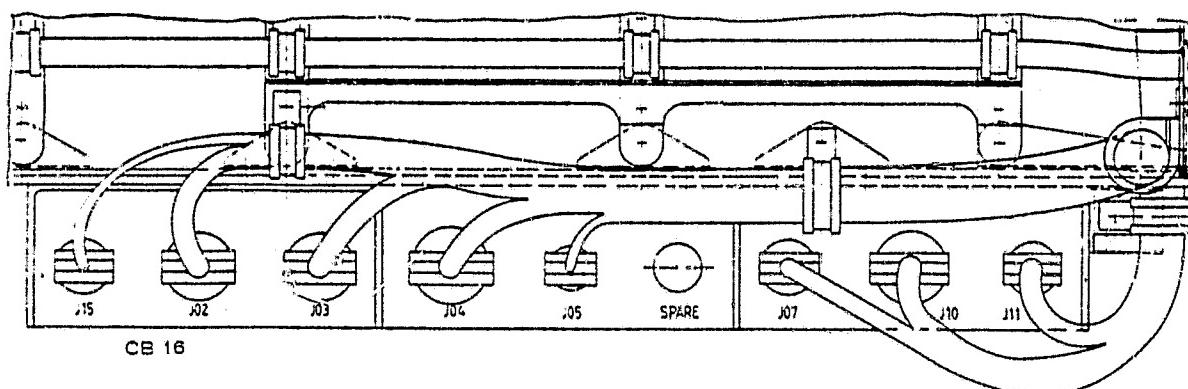


Figure 3.8 - 5e : Vicinity of CB 16

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The link to the experiment utility routings will be supplied in a later issue

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Figure 3.8 - 5a : Vicinity of CS 16

3.8.3 CPSE Connector Brackets

3.8.3.1 Connector Bracket CB 18

The location of CB 18 in the overhead structure is depicted in Figure 3.8 - 6a. Figure 3.8 - 6c shows the vicinity of CB 18 and the attachment to the overhead structure while Figure 3.8 - 6b gives the detailed panel lay-out. For functional description see section 3.7.1 of Appendix A.

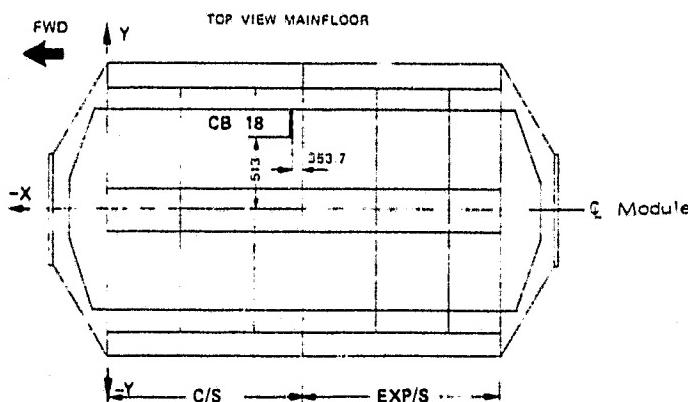
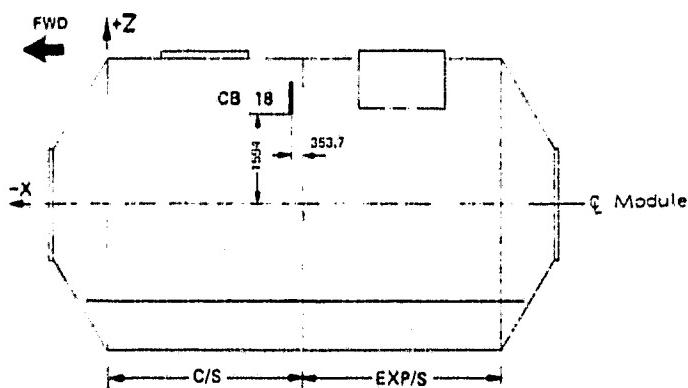


Figure 3.8 - 6a : Location of Connector Bracket CB 18

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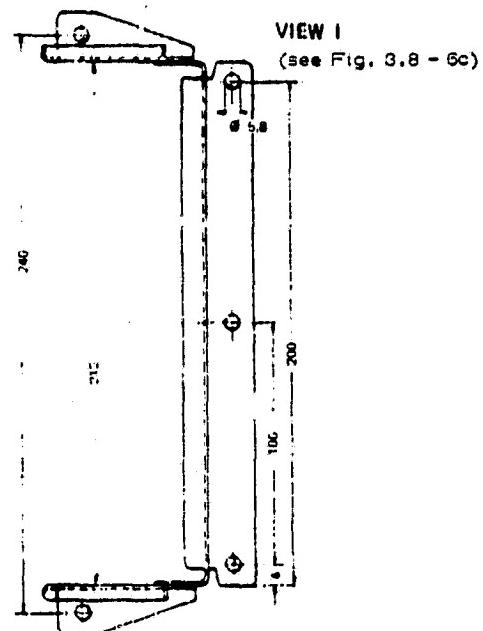
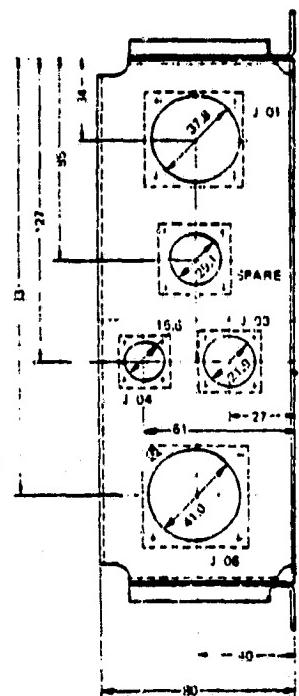


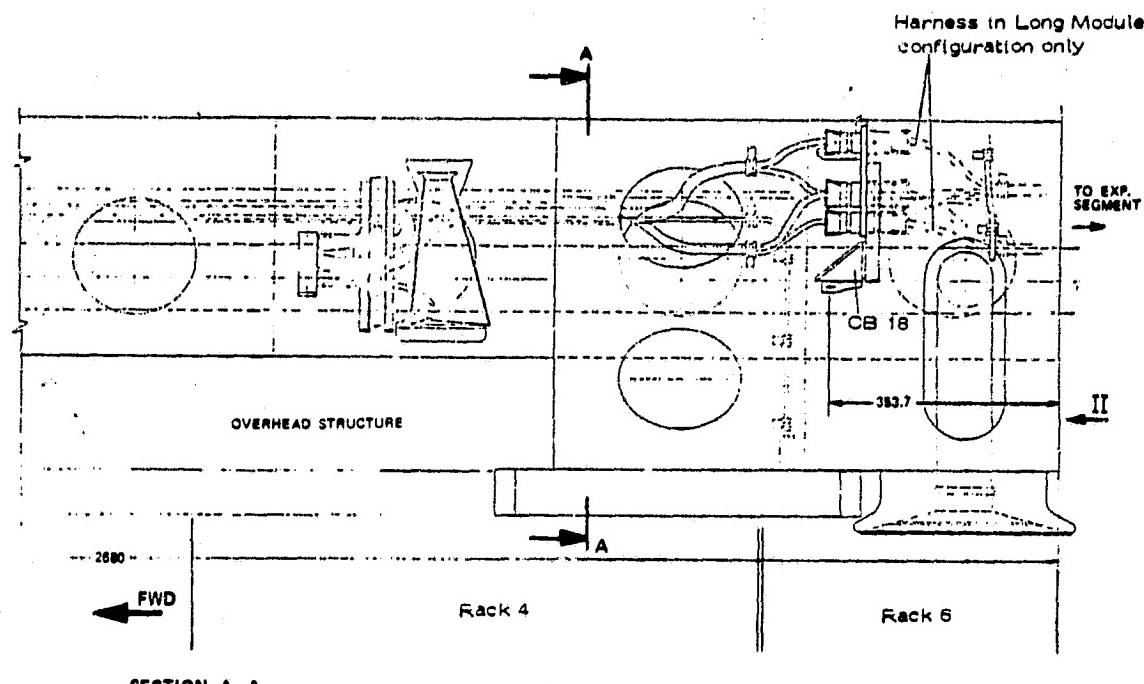
Figure 3.8 - 6b : Panel Lay-Out of CB 1a

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SECTION A-A

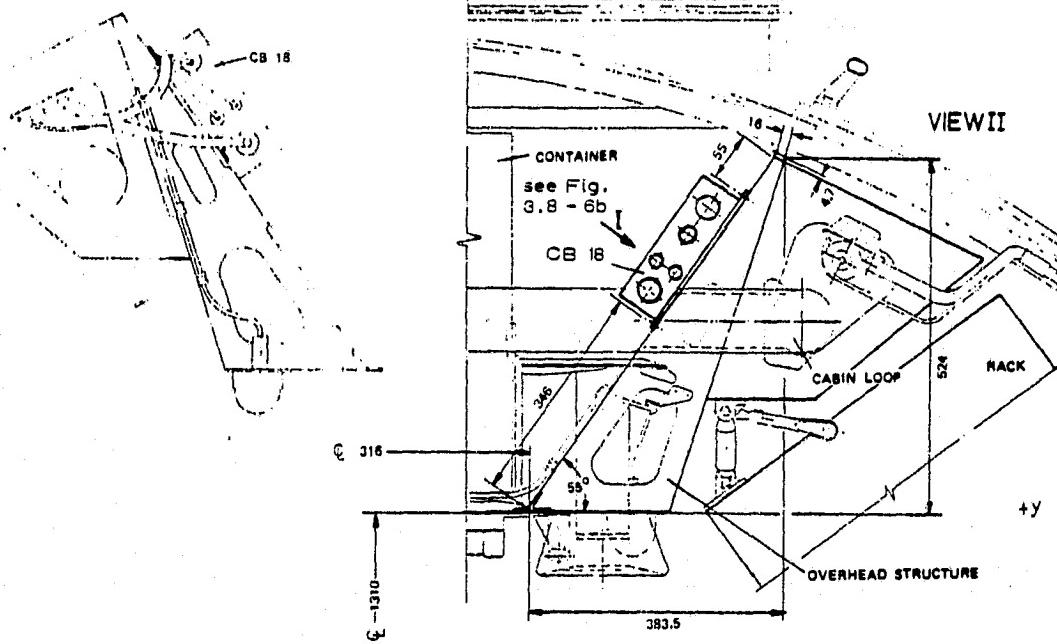


Figure 3.8 - 6c : Vicinity of CB 18

3.8.3.2 Connector Brackets CB 25 and CB 26

The connector brackets CB 25 and CB 26 are located in the overhead structure as depicted in Figure 3.8 - 7a. Both connector brackets are identical with respect to size and attachment to the overhead structure.

Figure 3.8 - 7c shows the vicinity of CB 25 and CB 26 while Figure 3.8 - 7b gives the detailed panel lay-outs and as an example the attachment of CB 25 to the overhead structure. For functional description see section 5.2 and 3.7.2 of Appendix A.

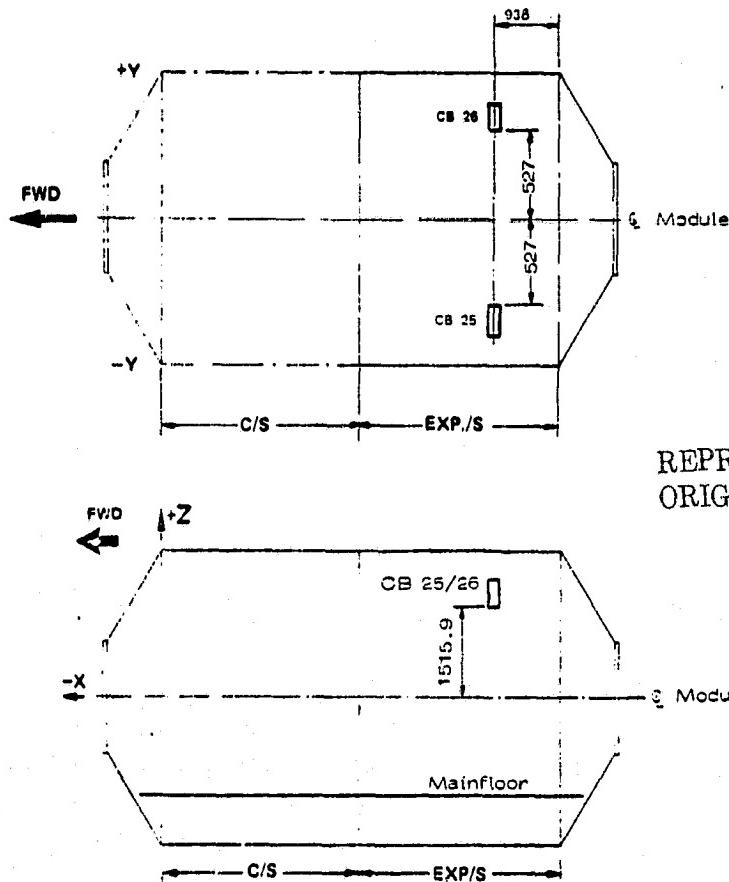


Figure 3.8 - 7a: Location of CB 25 and CB 26 in the Overhead Structure

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VIEW 1 see Fig. 3.8 - 7c

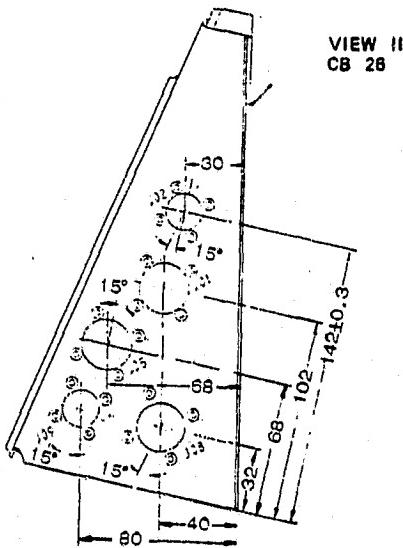
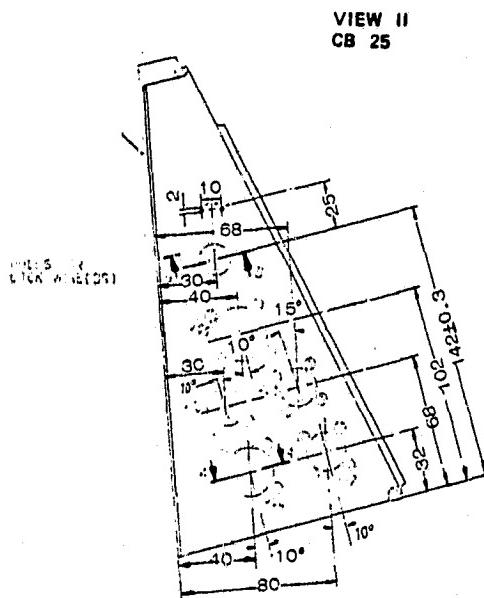
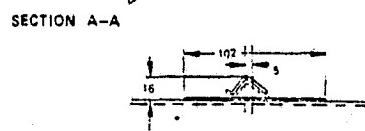
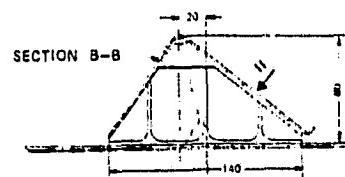
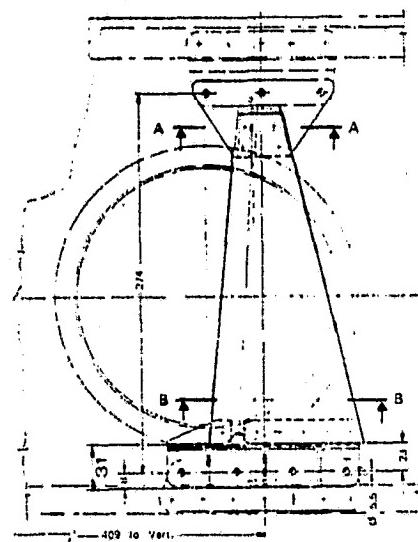


Figure 3.8 - 7b : Panel Lay-Out of CB 25 and CB 26

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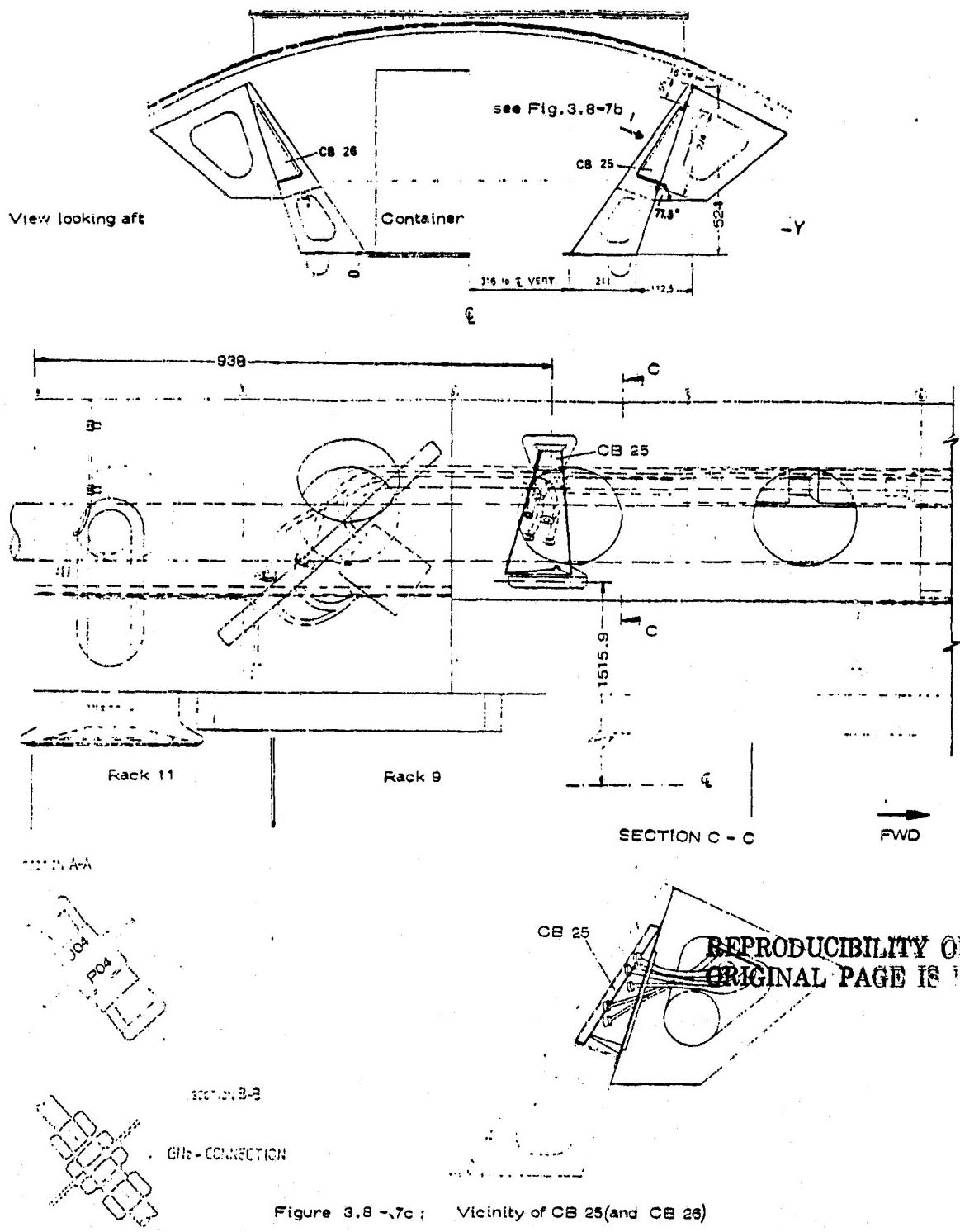


Figure 3.8 - 7c : Vicinity of CB 25 (and CB 26)

3.8.4 Aft End Cone Feedthrough

The user dedicated aft end cone feedthrough, CB 30, is depicted in Figure 3.8 - 8
The user dedicated utility routing envelopes (vicinity) of CB 30 are shown in Figure 3.8 - 9

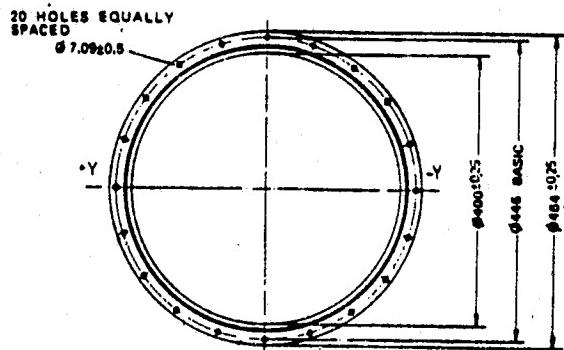
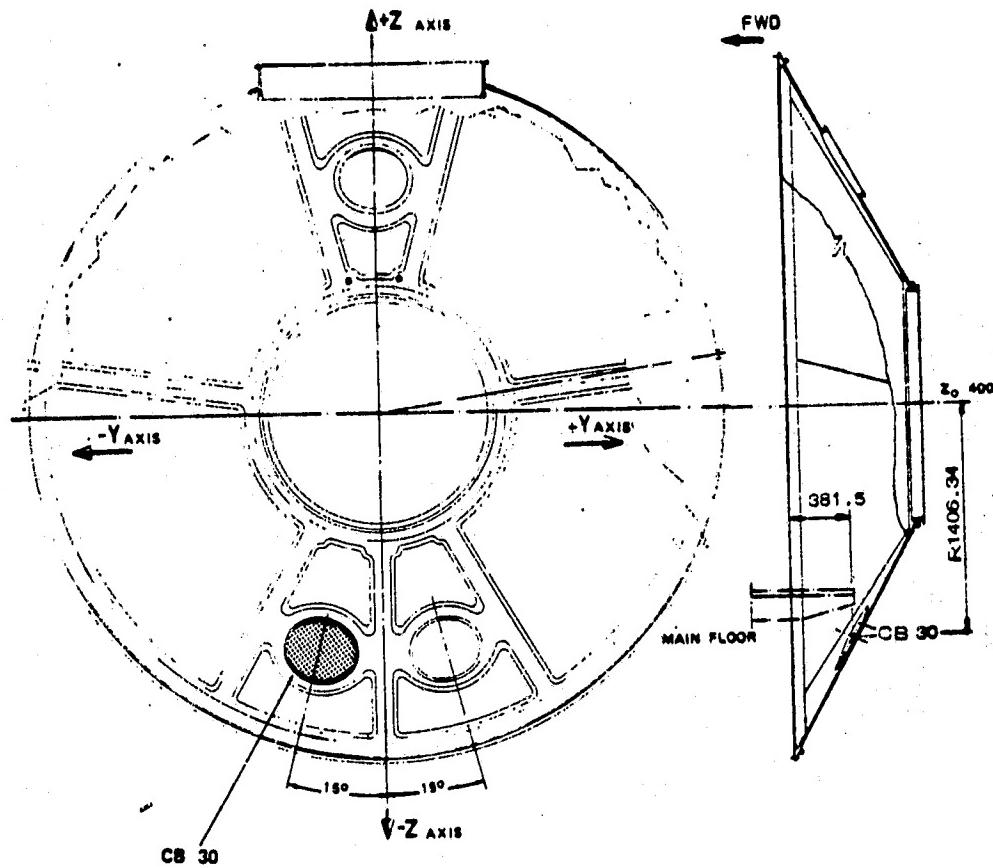


Figure 3.8 - 8: Aft End Cone Feedthrough, Connector Bracket CB 30
(User Dedicated Blank Plate)

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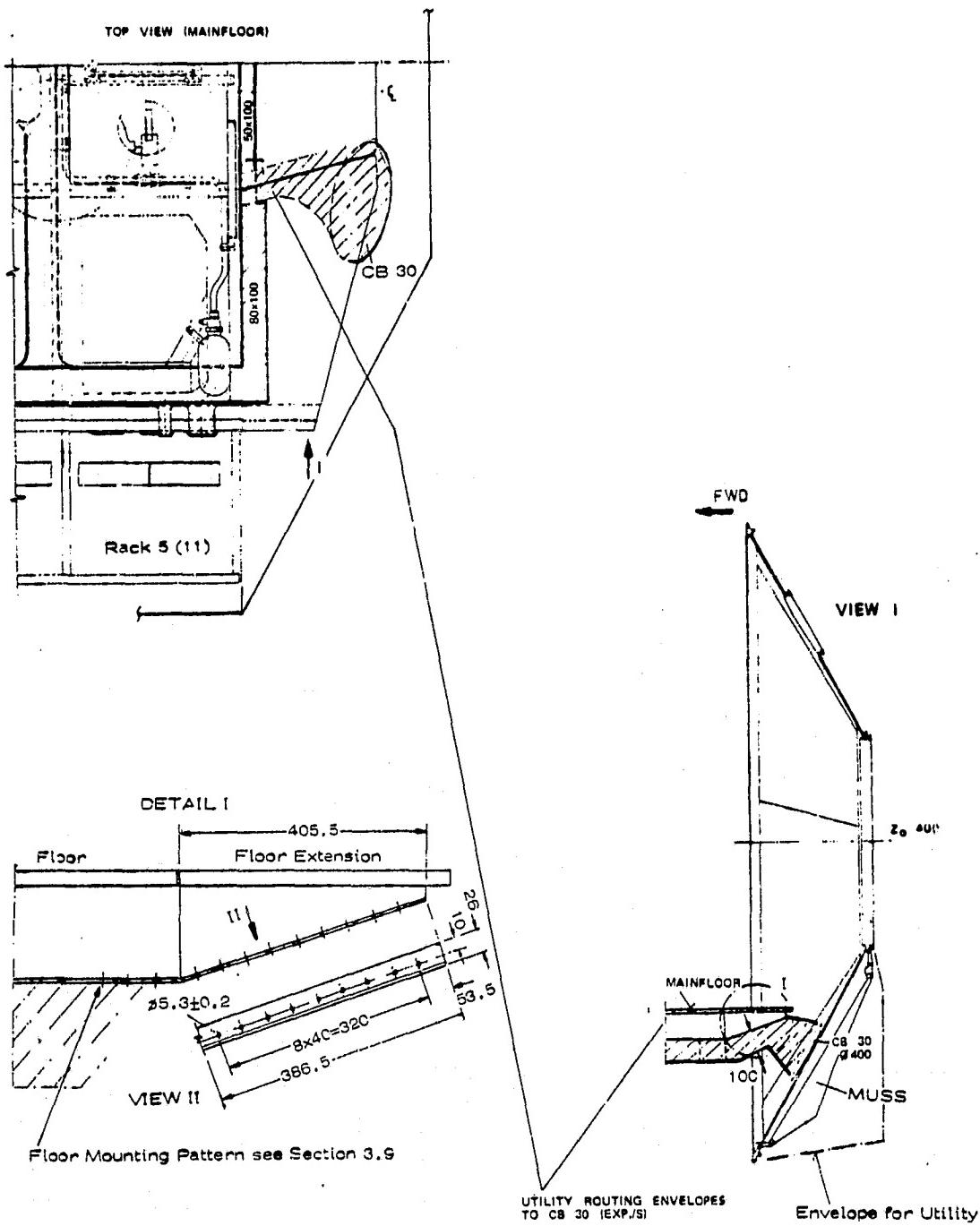


Figure 3.8-9: Vicinity of CB 30

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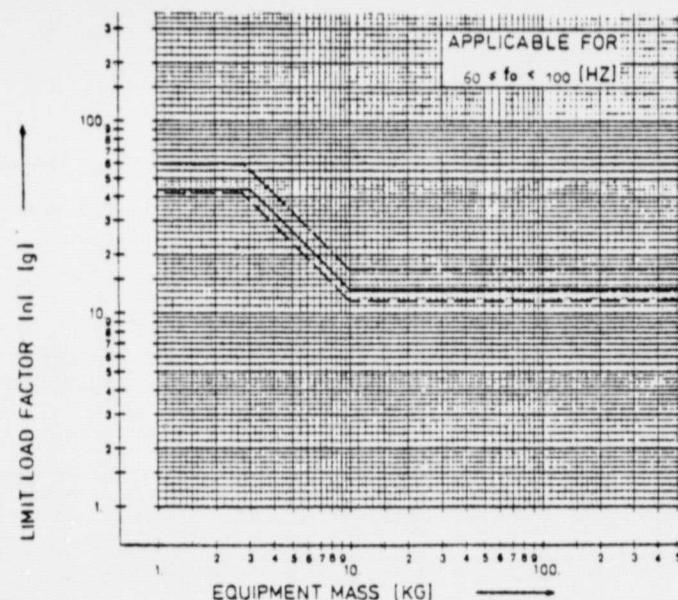
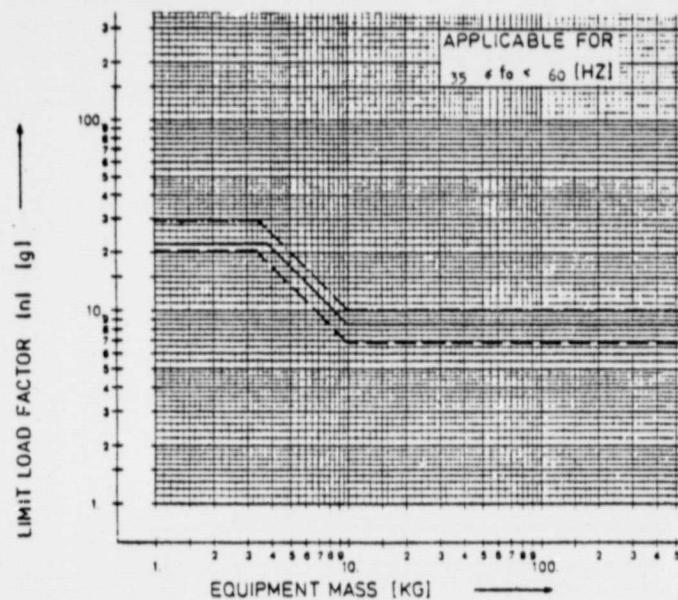
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3.8.5 Mechanical Environment

For the mechanical environment of CB 5, CB 50 which are mounted on the honeycomb structure of the subfloor, see Figure 3.8-10a and 10b

For the mechanical environments of the remaining connector brackets, see the respective sections:

- For CB 31 and CB 32 see para. 3.3.1.5.1
- For CB 6, CB 16 and CB 26, which are mounted on the floor structure, see para. 3.3.1.5.1
- For CB 26, CB 25 and CB 18 mounted on the overhead structure, see para. 3.4.5
- For CB 30, mounted on the aft end cone, see para. 3.6.2.6
- For rack bottom connector brackets see para. 3.2.7
- And for the airlock connector brackets, see para. 3.6.3.6.



$|n_x|$ —————
 $|n_y|$ - - - - -
 $|n_z|$ - - - - -

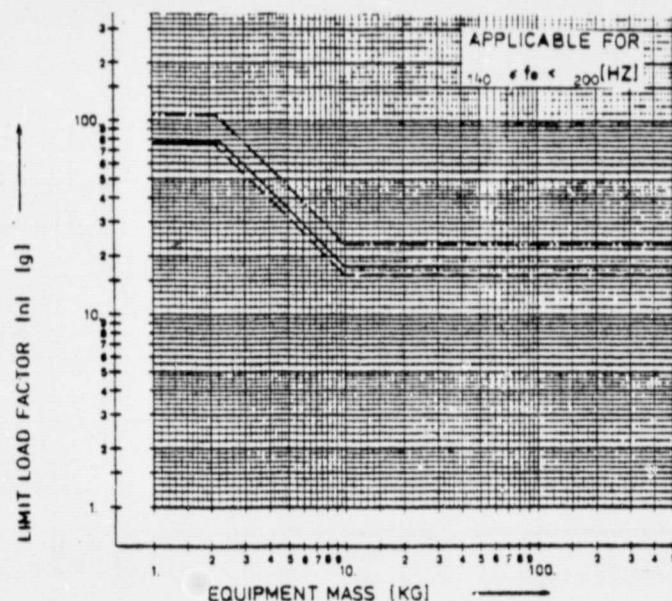
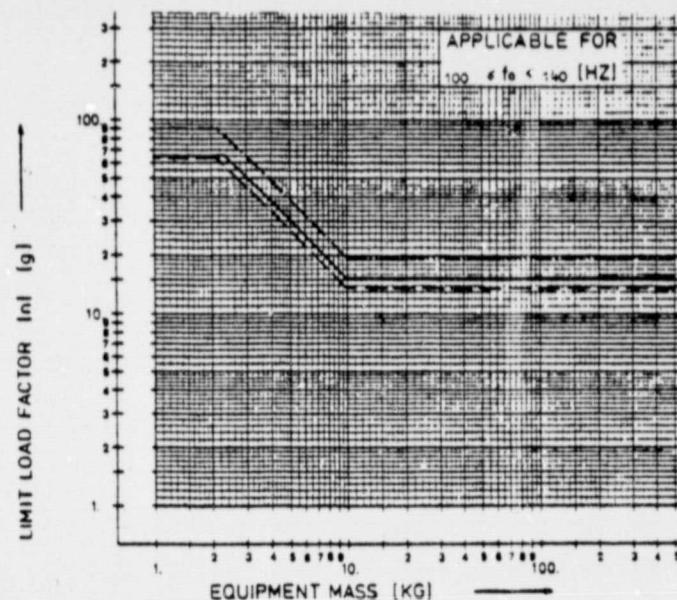
$|n|$ ACTING AT
EQUIPMENT C.G.

$j=1.0$

($|n|$ = absolute values)

(see also para 3.2.7)

Figure 3.7 - 10a: Limit Load Factor Diagrams for Dimensioning of Brackets,
Zone "Floor Honeycomb Subfloor"



$|ln_x|$ —————
 $|ln_y|$ - - - - -
 $|ln_z|$ - - - - -

$|ln|$ ACTING AT
EQUIPMENT C.G.

$j=1.0$

($|n|$ = absolute values)

(see also para 3.2.7)

Figure 3.7 - 10b: Limit Load Factor Diagram for Dimensioning of Brackets,
Zone "Floor Honeycomb Subfloor"

3.9 Module Utility Routing Provision

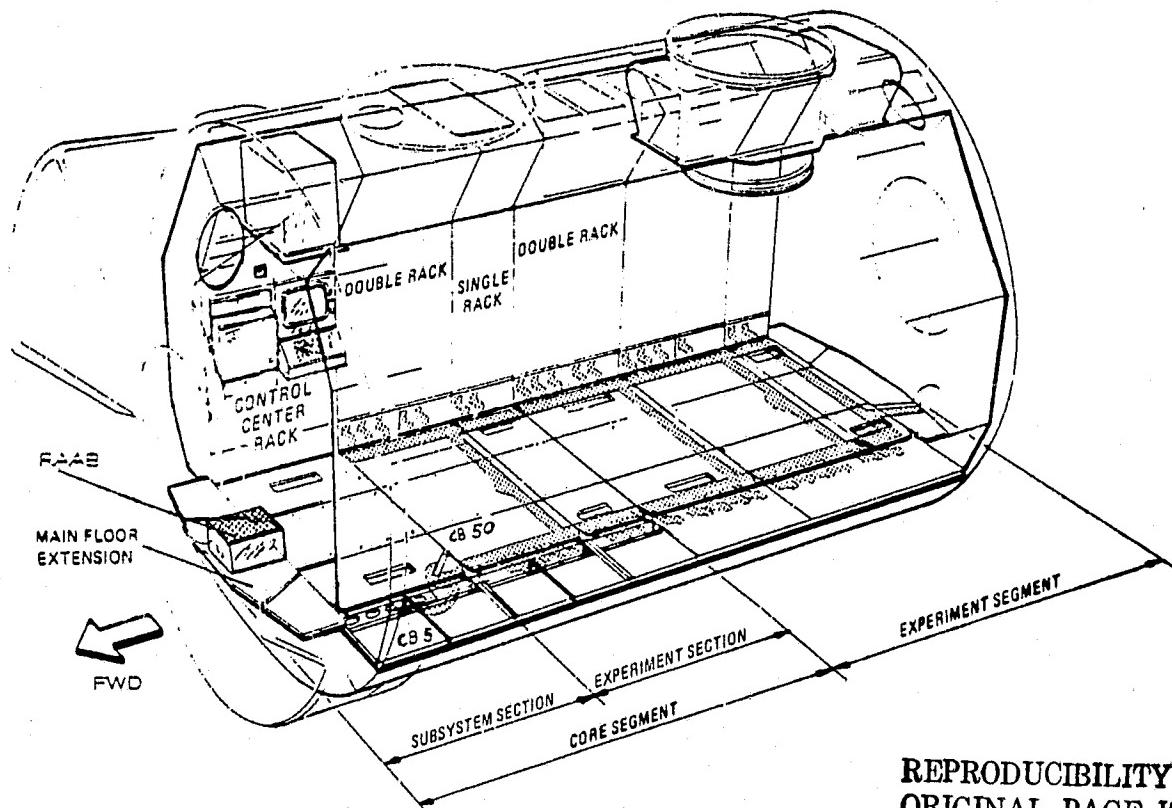
3.9.1 Main Floor Routing

Under the module main floor there are provisions for experiment utilities to be routed between

- Racks
- Center aisle
- Spacelab subsystems (CB 5, CB 50, etc.)
- Pallet
- AFD

The provisions comprise the definition of envelopes reserved for experiment utilities and the definition of dedicated attachment points.

The cabling and/or plumbing itself and any necessary support devices - such as cable trays, clamps, and fasteners - have to be provided by the experimenter/payload integrator.



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Figure 3.9 - 1 Utility Routing Envelopes

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3.9.1.1 Main Floor Experiment Utility Envelopes

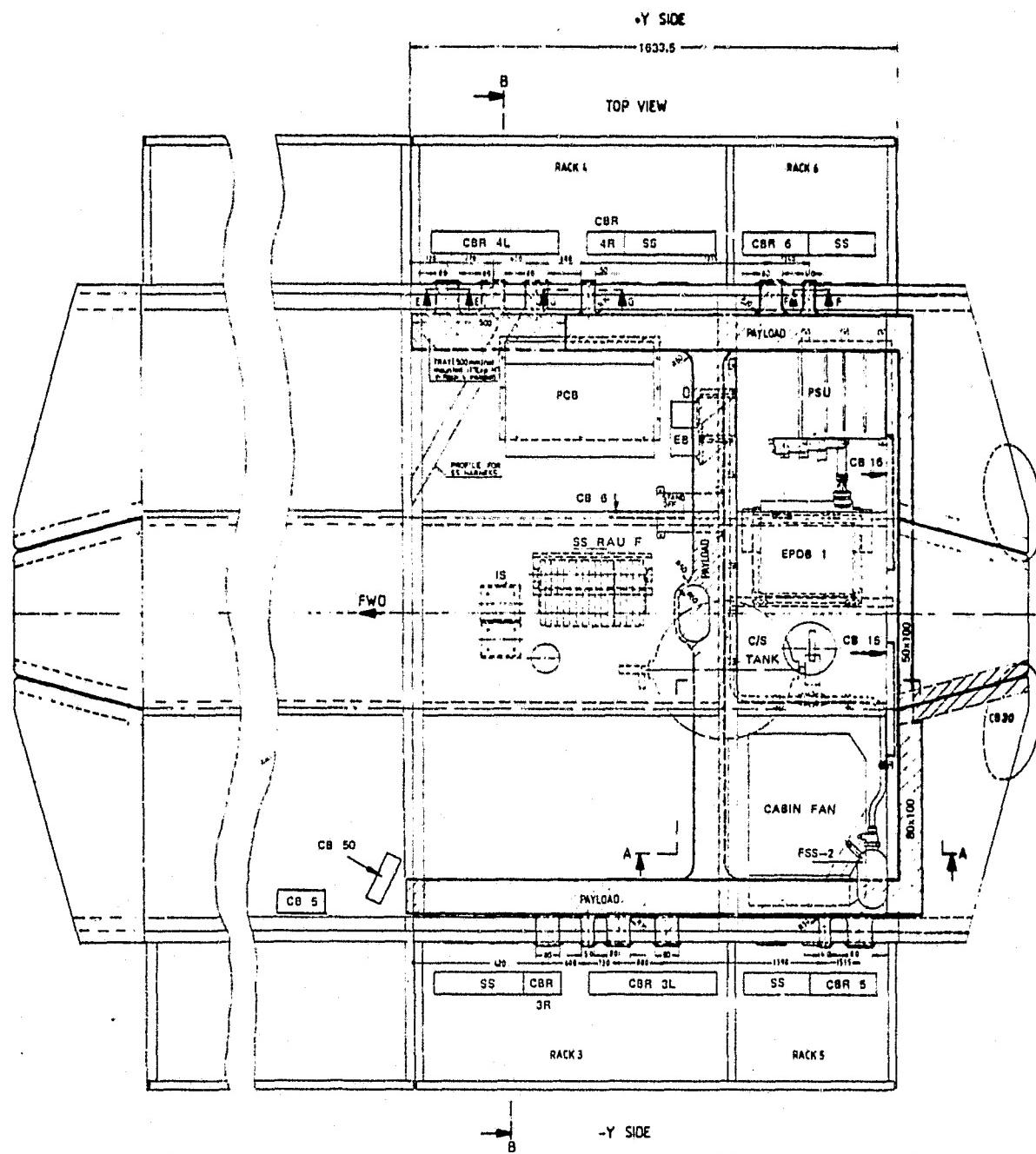


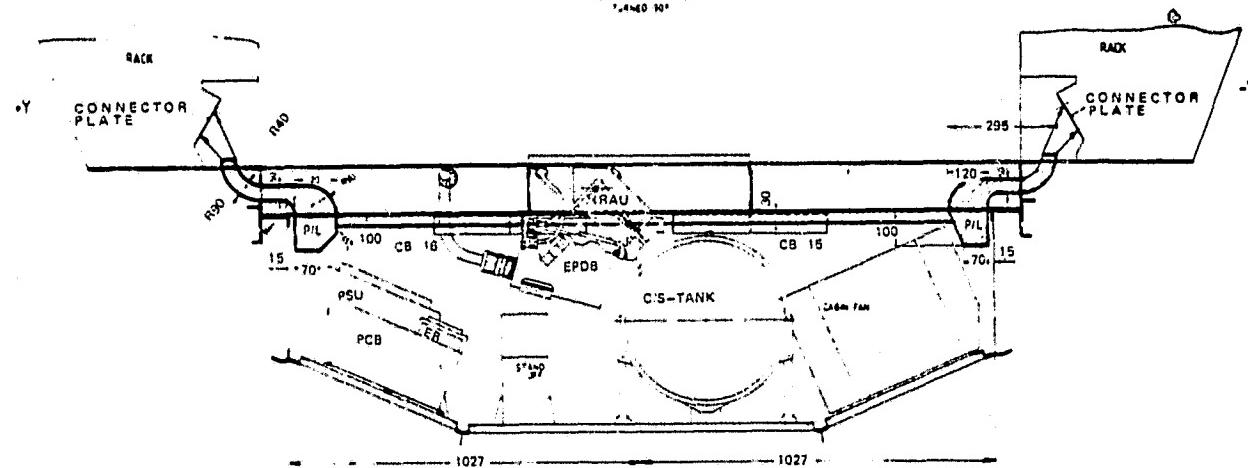
Figure 3.9 - 2a : Utility Routing Envelopes-Core Segment (Plan View)

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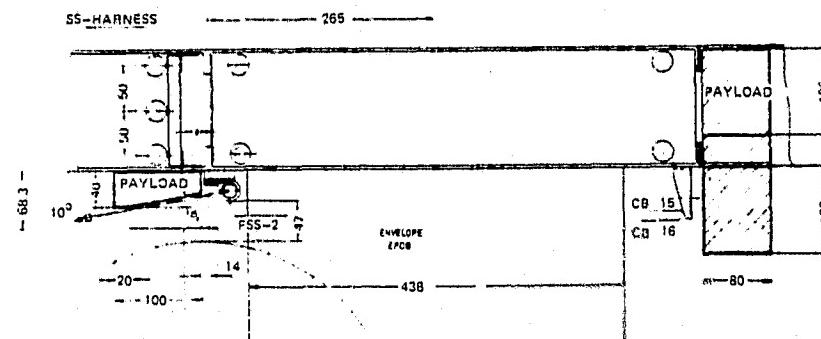
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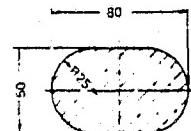
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SECTION A-A



SECTION E-E, F-F, G-G



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Figure 3.9 - 2b: Utility Routing Envelopes-Core Segment (Cross Section)

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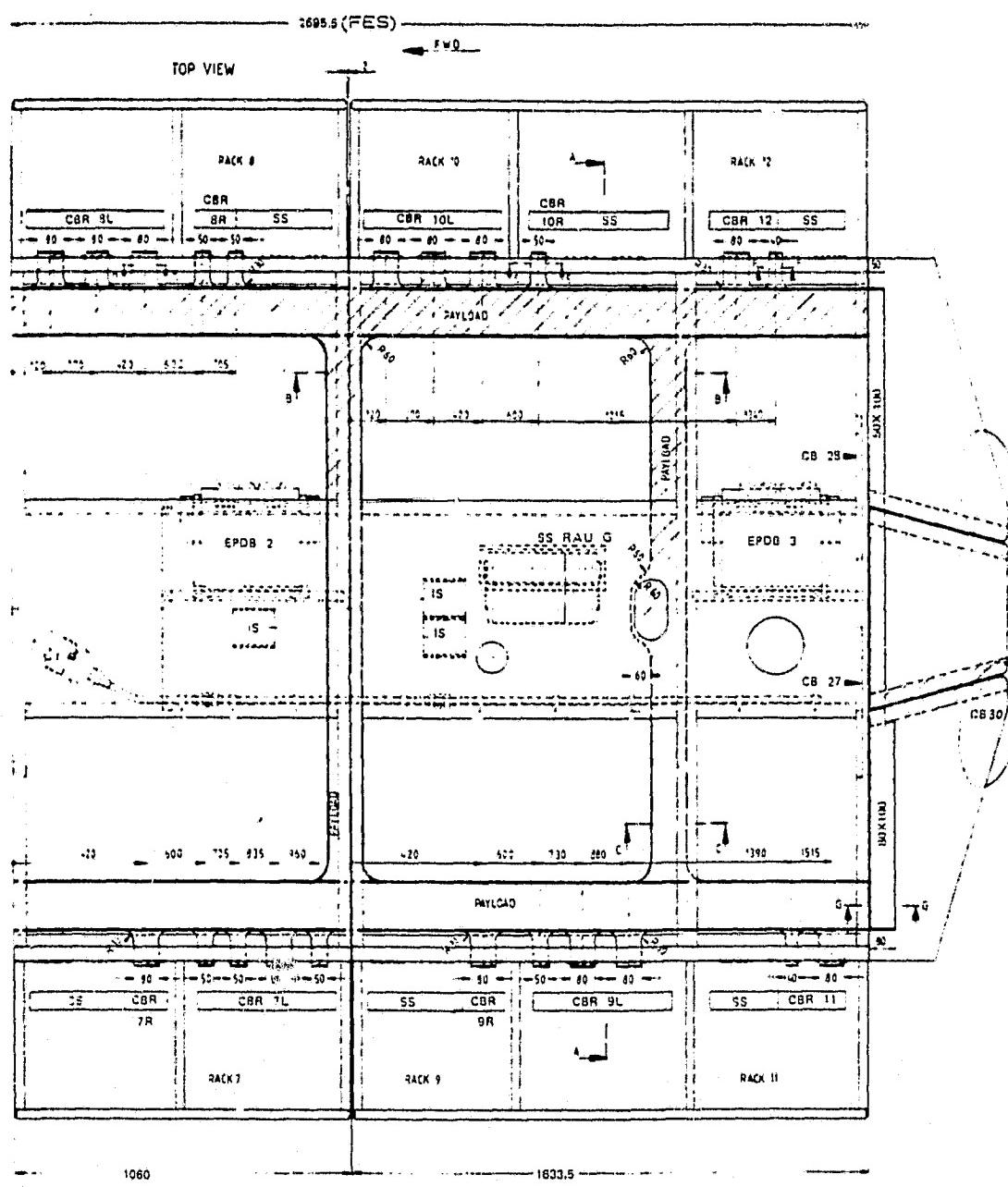


Figure 3.9 - 3a : Utility Routing Envelopes-Experiment Segment (Plan View)

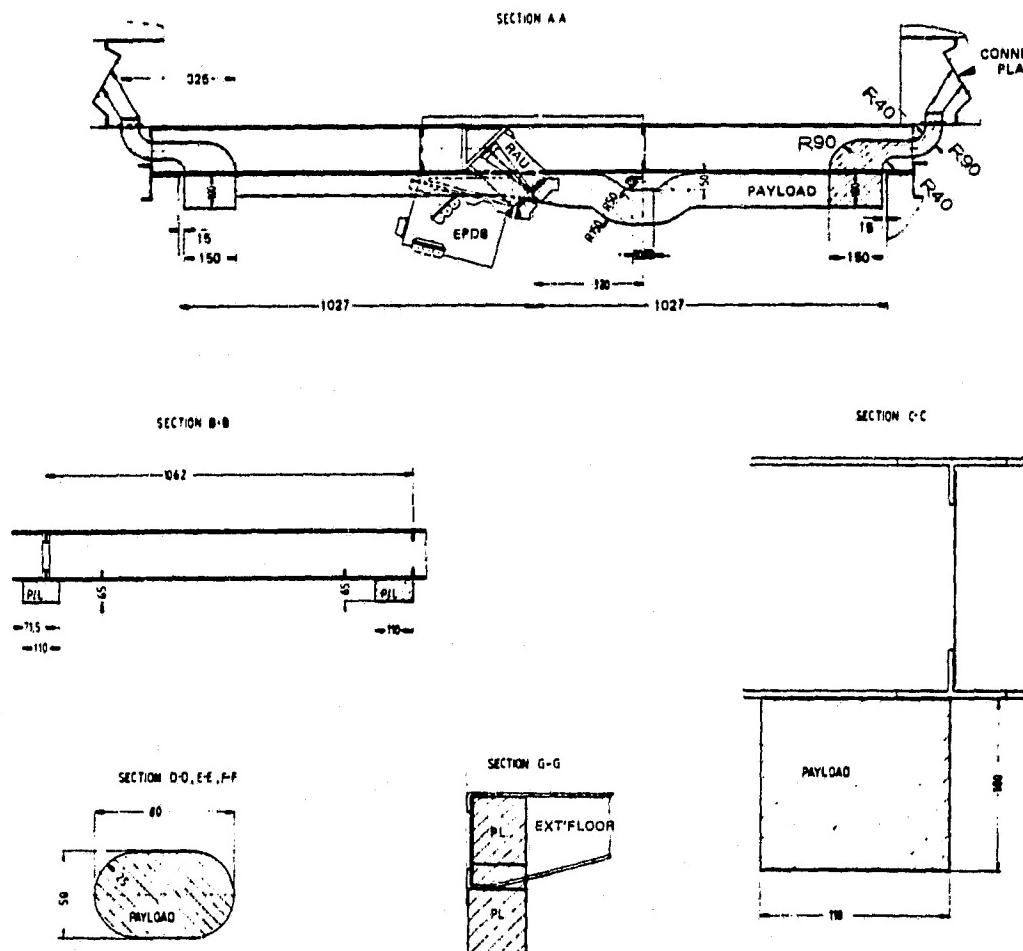


Figure 3.9 - 3b : Utility Routing Envelopes-Experiment Segment (Cross Section)

3.9.1.2 Main Floor Utility Attachment Provisions

These are attachment holes in the transverse beams of the main floor structure which are for the attachment of utilities and utility support structure. The attachment to these holes will be performed by user provided M 5 bolts and nuts.

The location of these attachment holes is shown in Figure 3.9 - 4.

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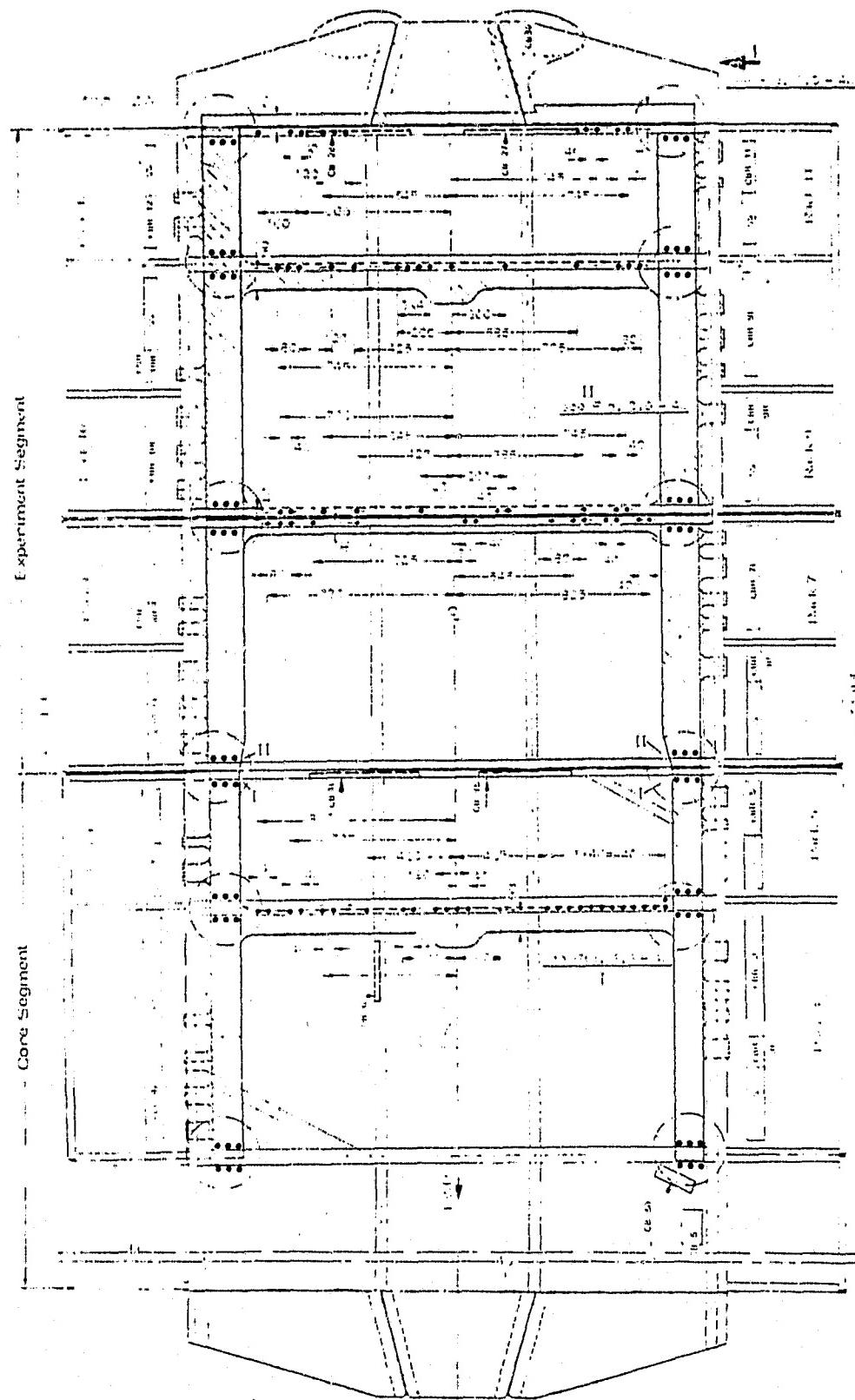
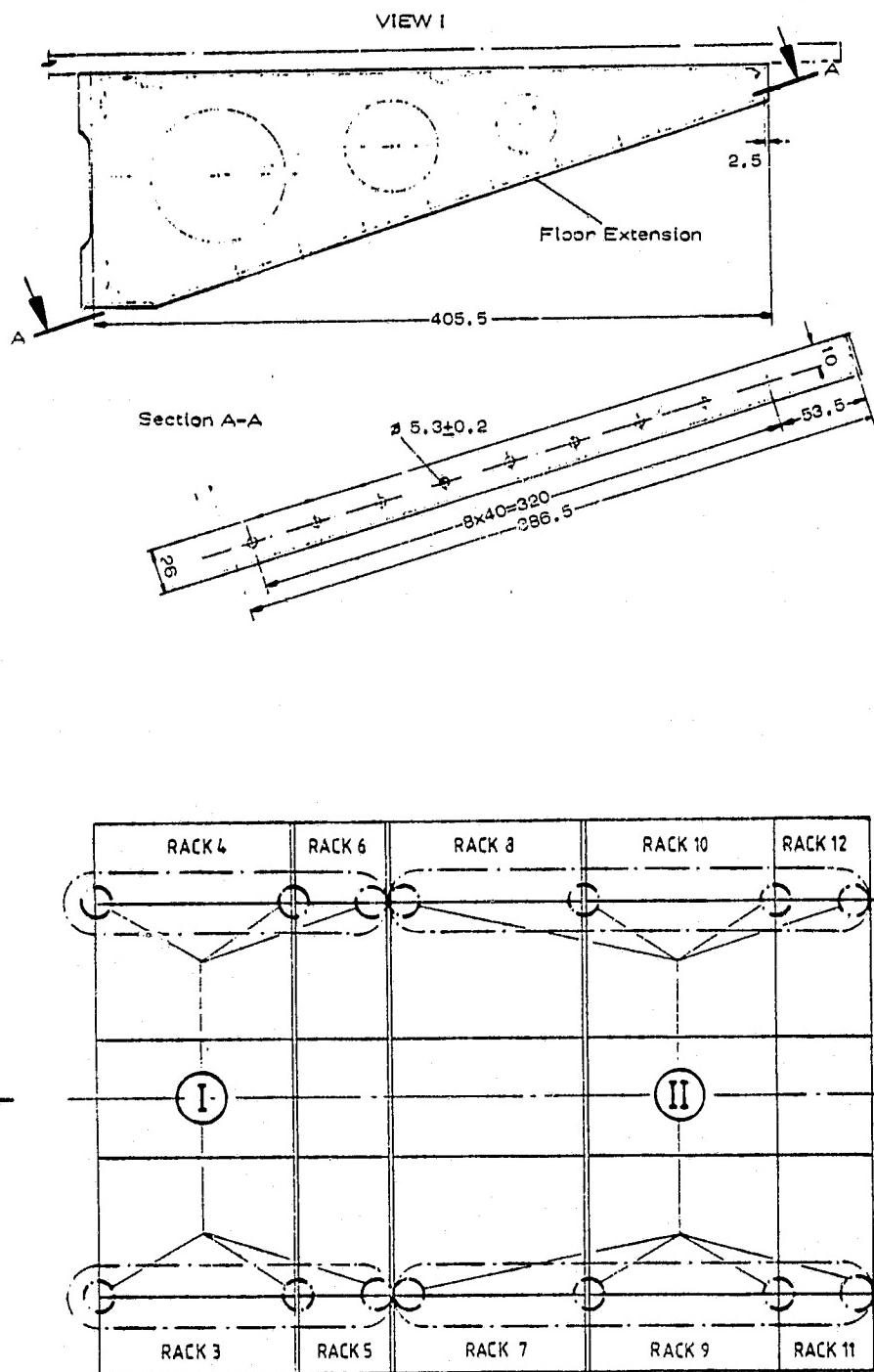


Figure 3.9 – 4a : Utility Routing Attachment Provisions

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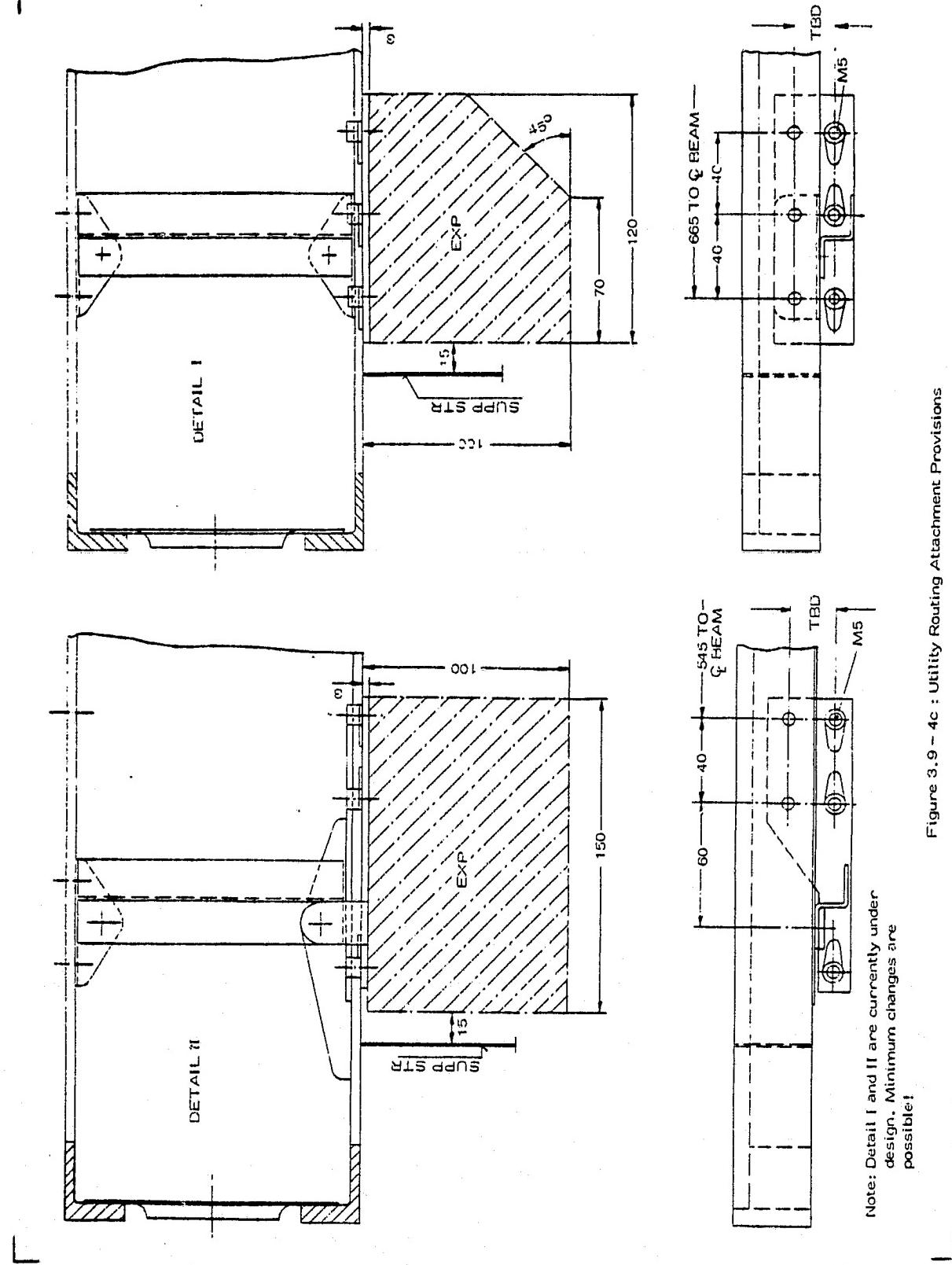
Detail I and II see Fig. 3.9 - 4c

Figure 3.9 - 4b : Utility Routing Attachment Provisions

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Note: Detail I and II are currently under design. Minimum changes are possible!

Figure 3.9 - 4c : Utility Routing Attachment Provisions

3.9.2 Vent Line Routing

Experimenter provided vent lines can be routed to the experiment vent valve along the upper parts of the racks as shown in Figure 3.9 - 5.

The experiment vent line can be routed from the starboard side as well as from the port side.

It is possible to accommodate a vent line of up to 60 mm outer diameter without interference with rack equipment. Only in the vicinity of the airlock interference with equipment in upper part of the racks cannot be avoided.

The Spacelab provisions for vent line routing comprise the definition of envelopes reserved for vent lines and the definition of mechanical attachment points.

The vent line itself and any necessary support device - such as brackets, clamps, and fasteners - have to be provided by the experimenter/payload integrator.

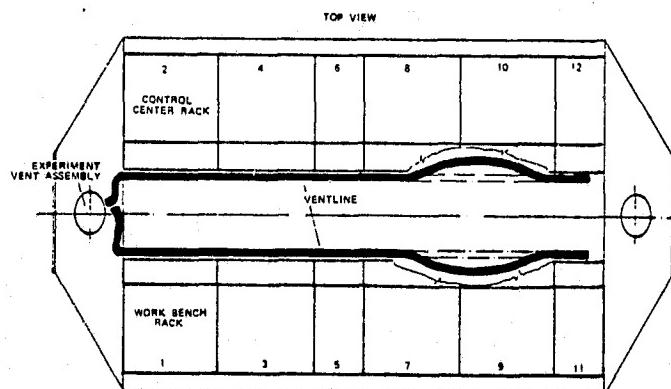
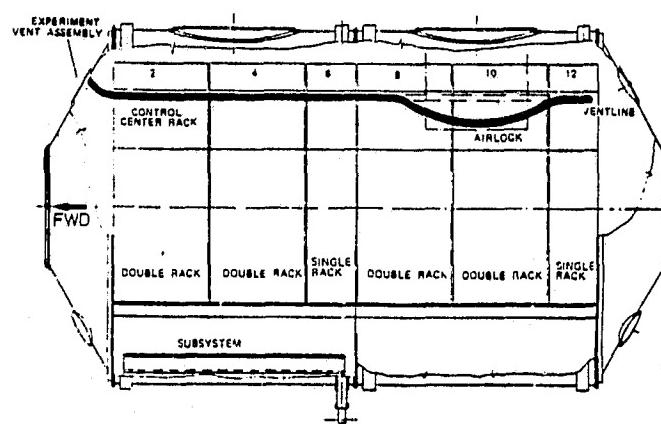


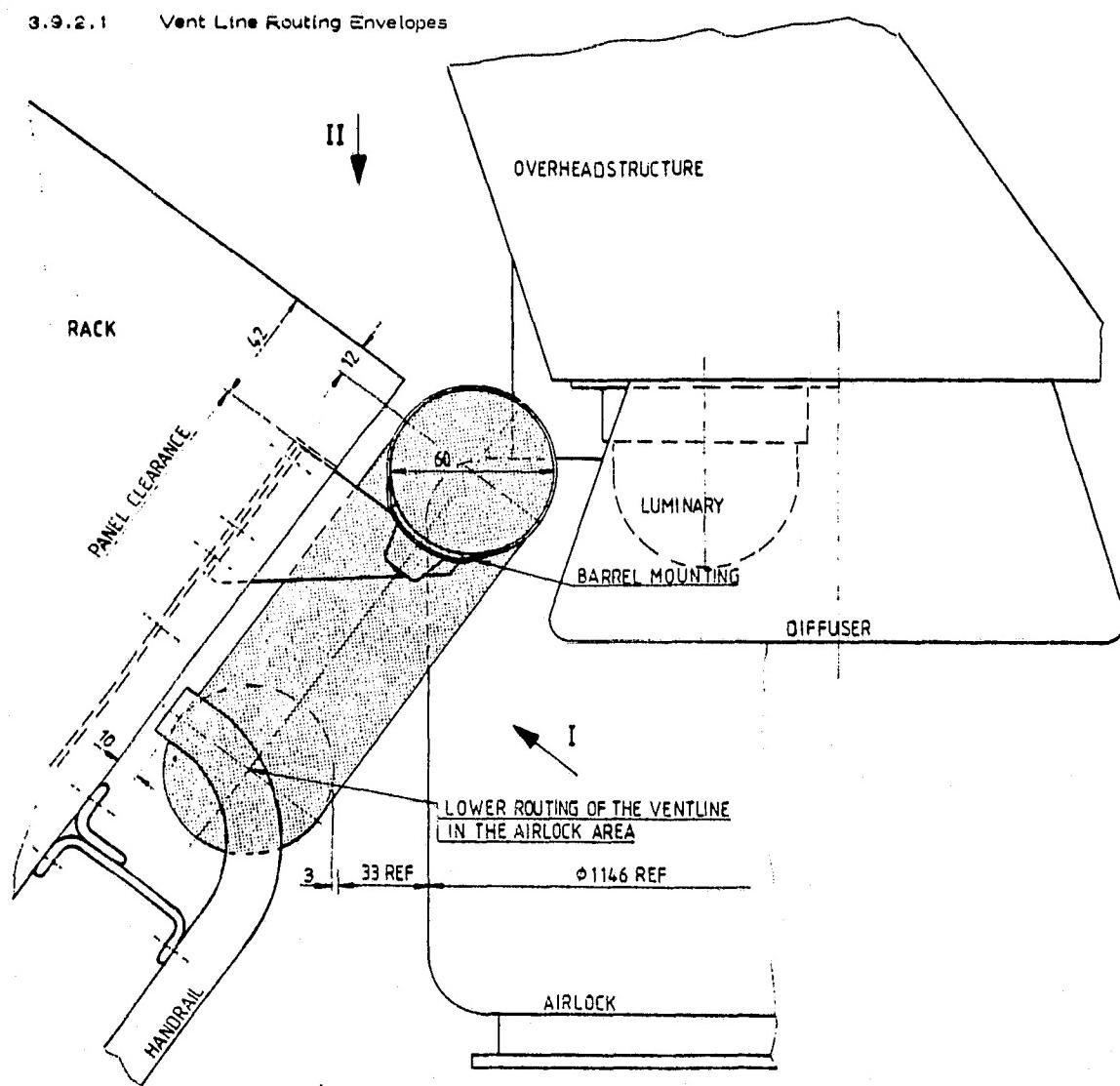
Figure 3.9 - 5a : Vent Line Routing Concept

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3.9.2.1 Vent Line Routing Envelopes



User provided

Figure 3.9 - 5b : Routing at Rack Upper Part

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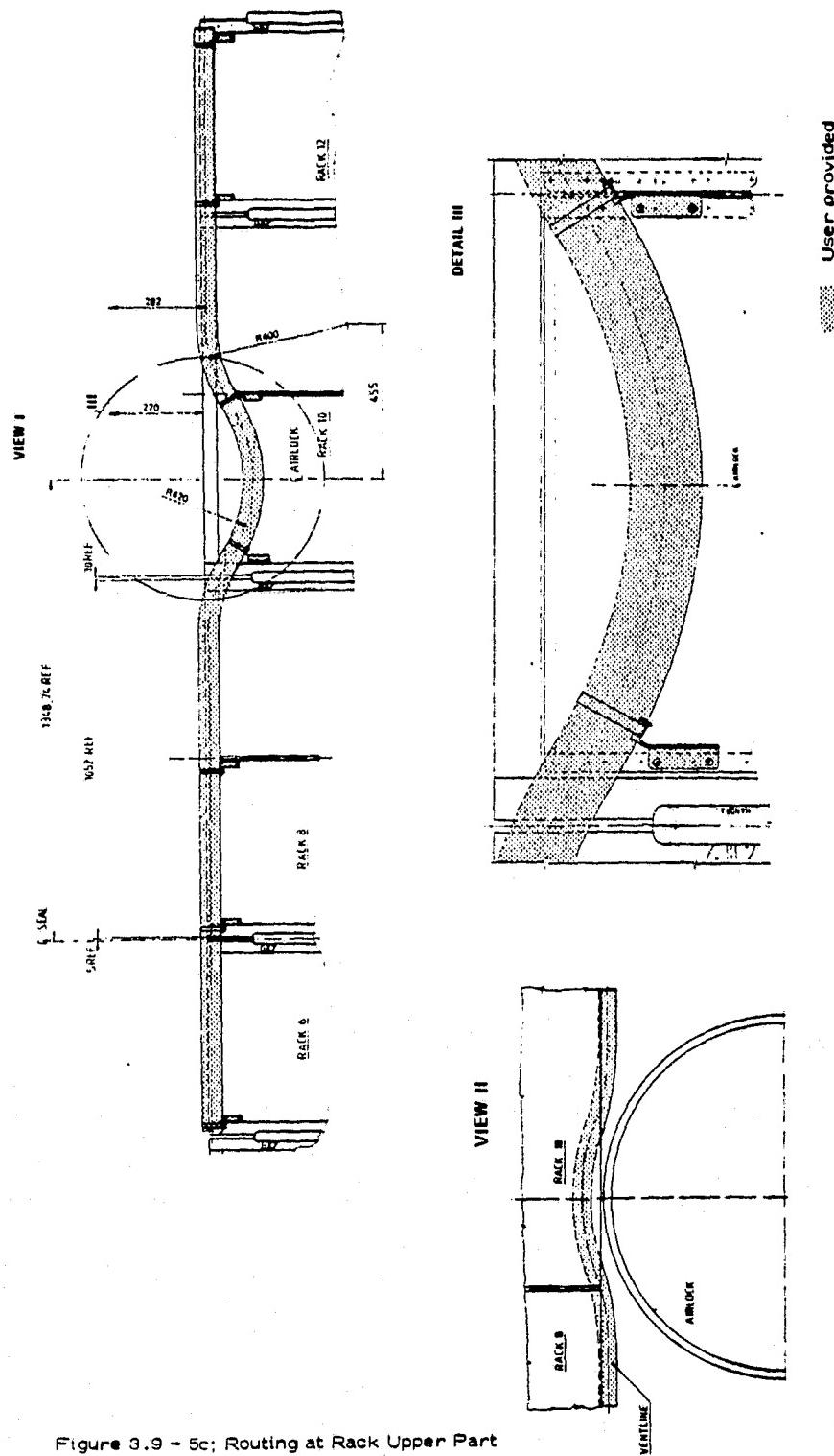


Figure 3.9 - 5c; Routing at Rack Upper Part

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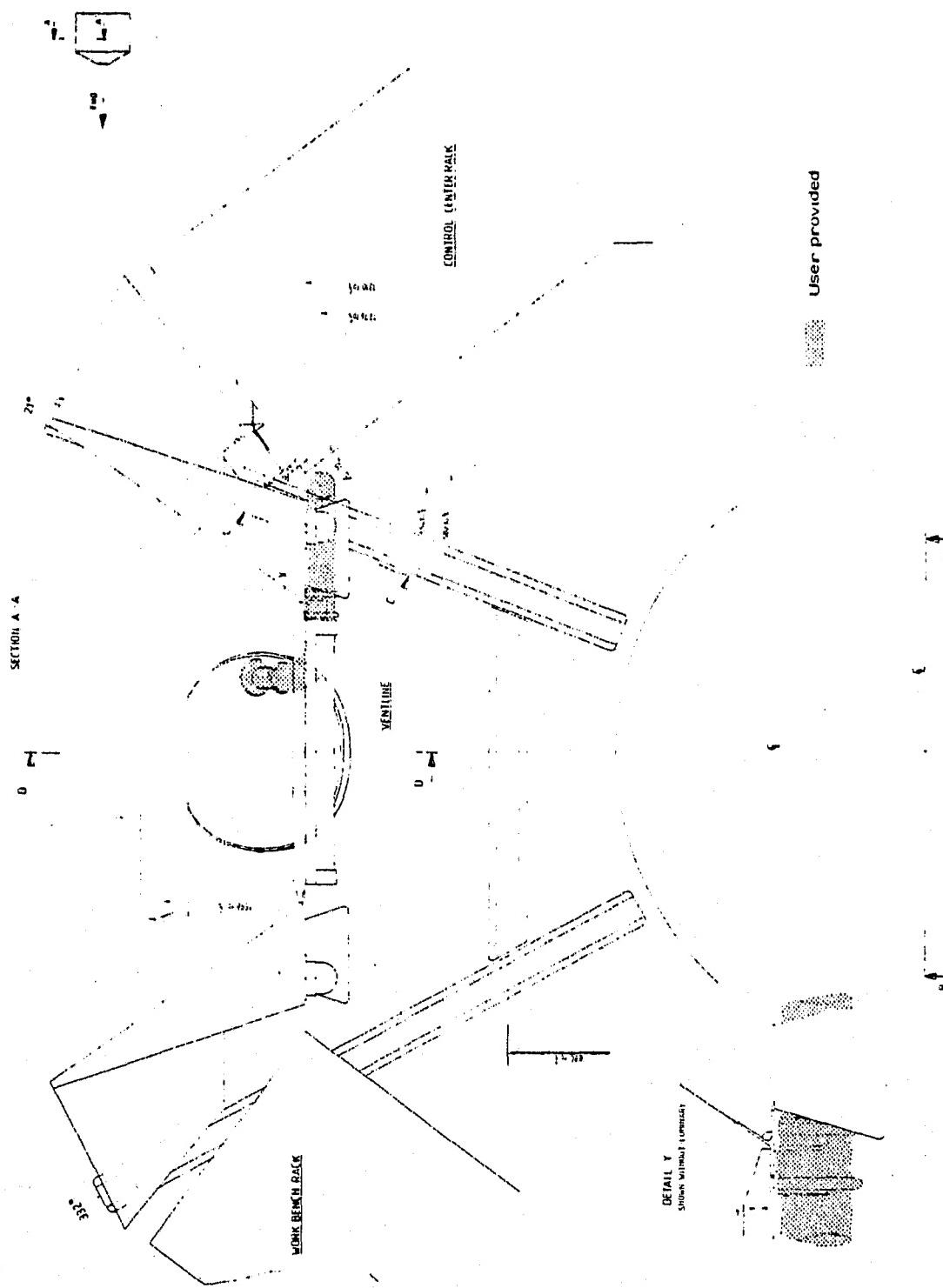


Figure 3.9 - 5d: Vent Line Routing from Starboard , Forward View

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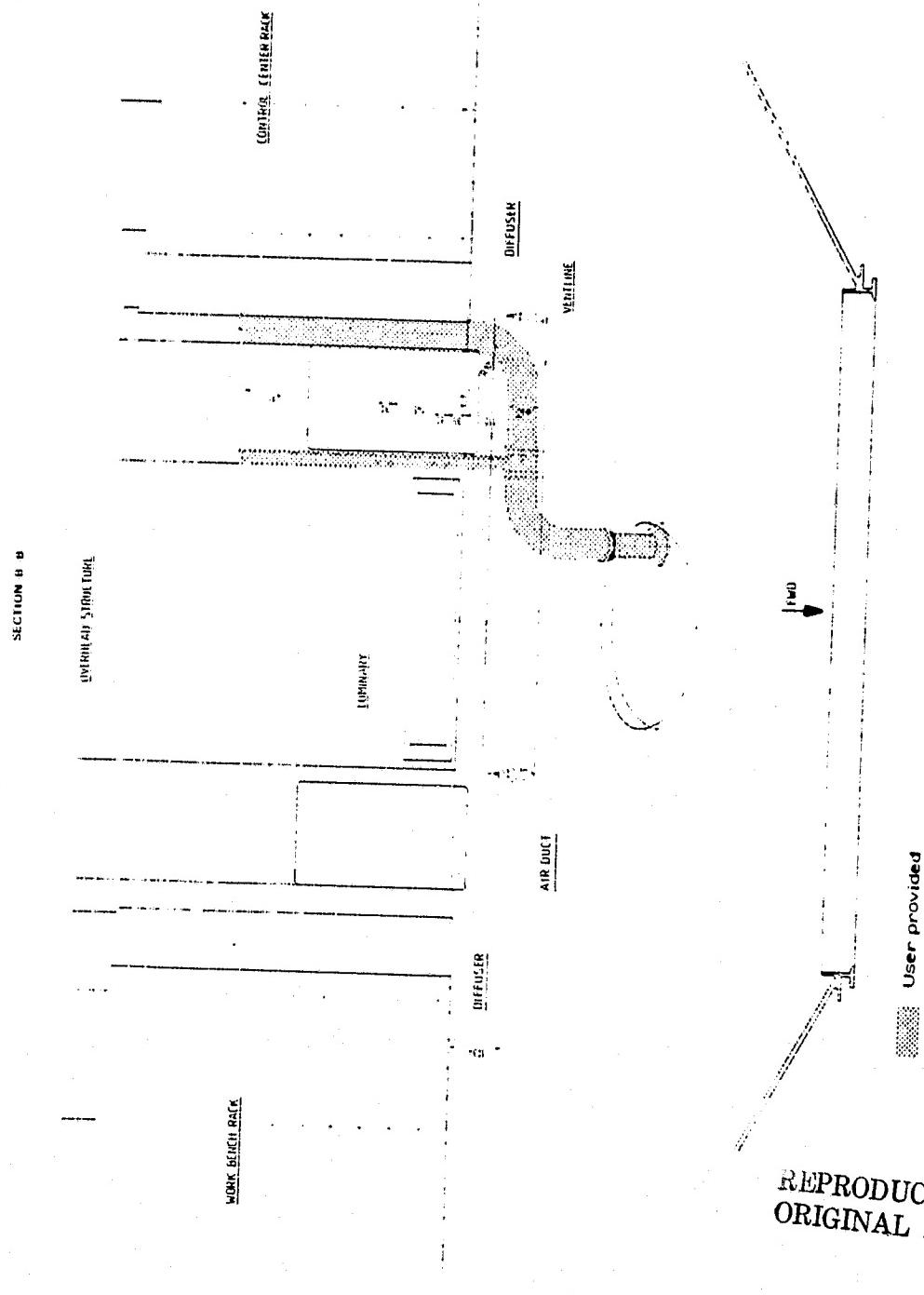


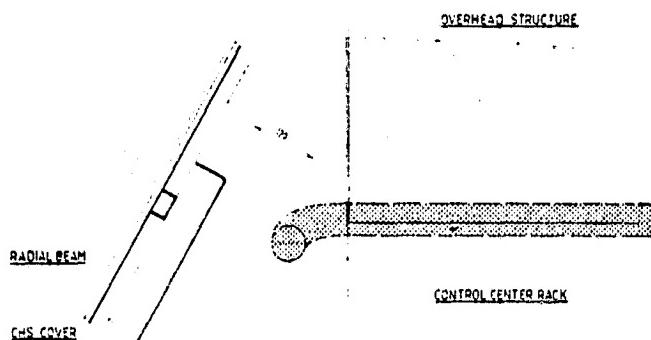
Figure 3.9 - 5e : Vent Line Routing from Starboard , View to Top

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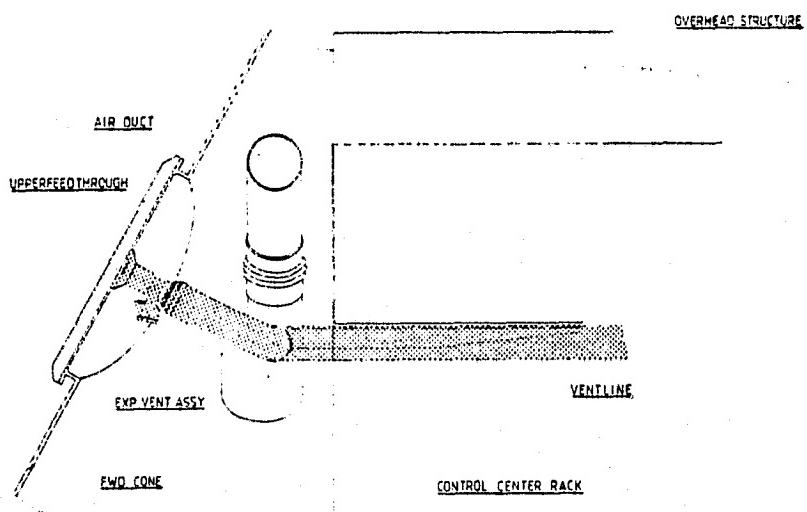
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Figure 3.9 - 5f : Vent Line Routing from Starboard Side , Side View

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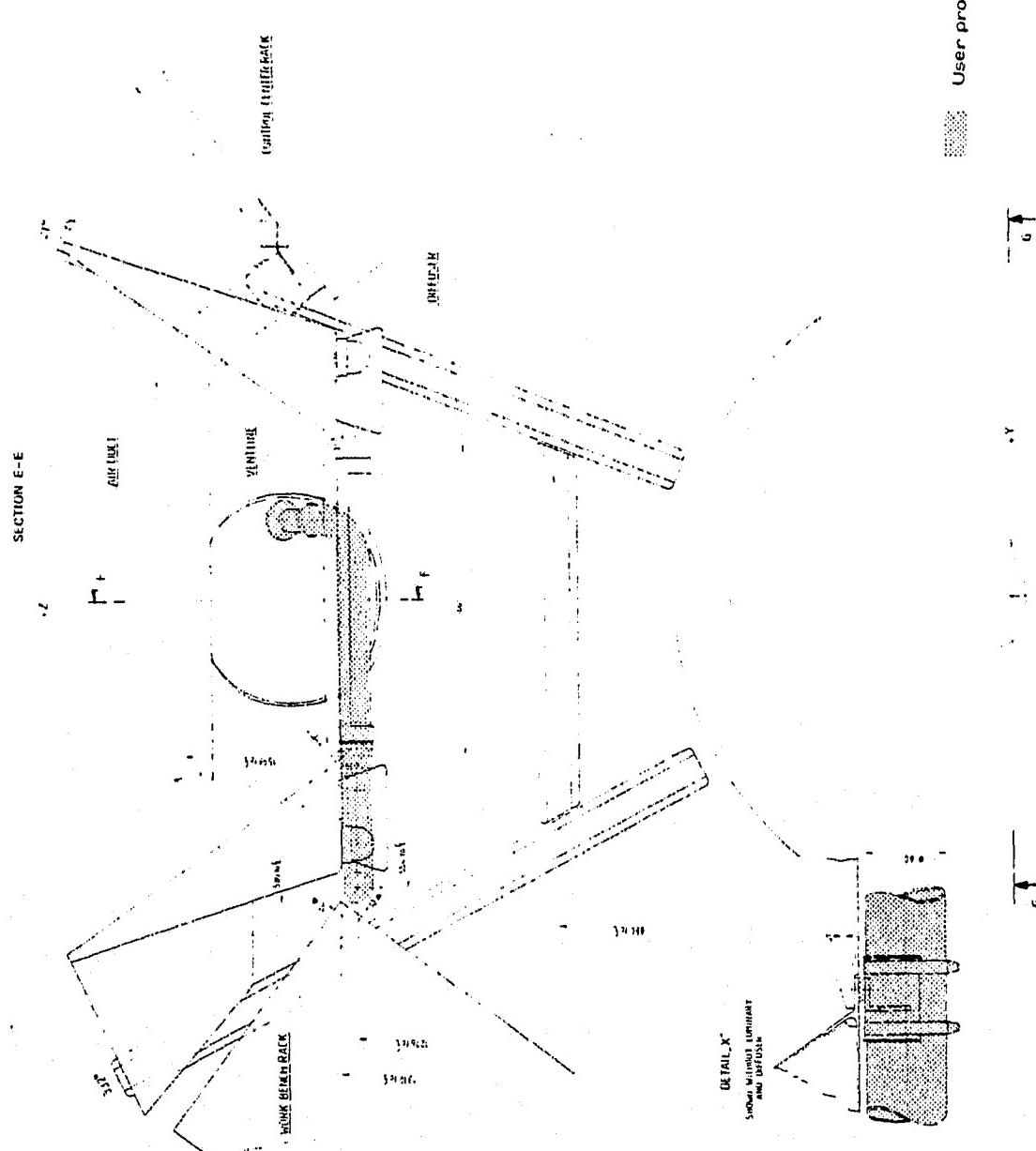


Figure 3.9 – 5g : Vent Line Routing from Port Side , Forward View

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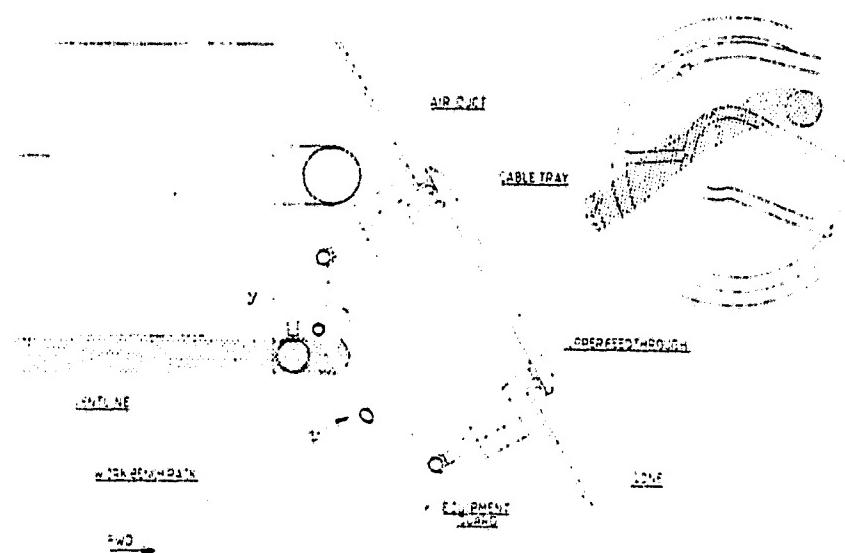
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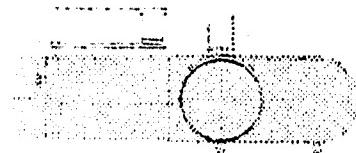
OVERHEAD STRUCTURE

VIEW 2



DETAIL Y
PORT SIDE EQUIPMENT GUARD

OVERHEAD STRUCTURE



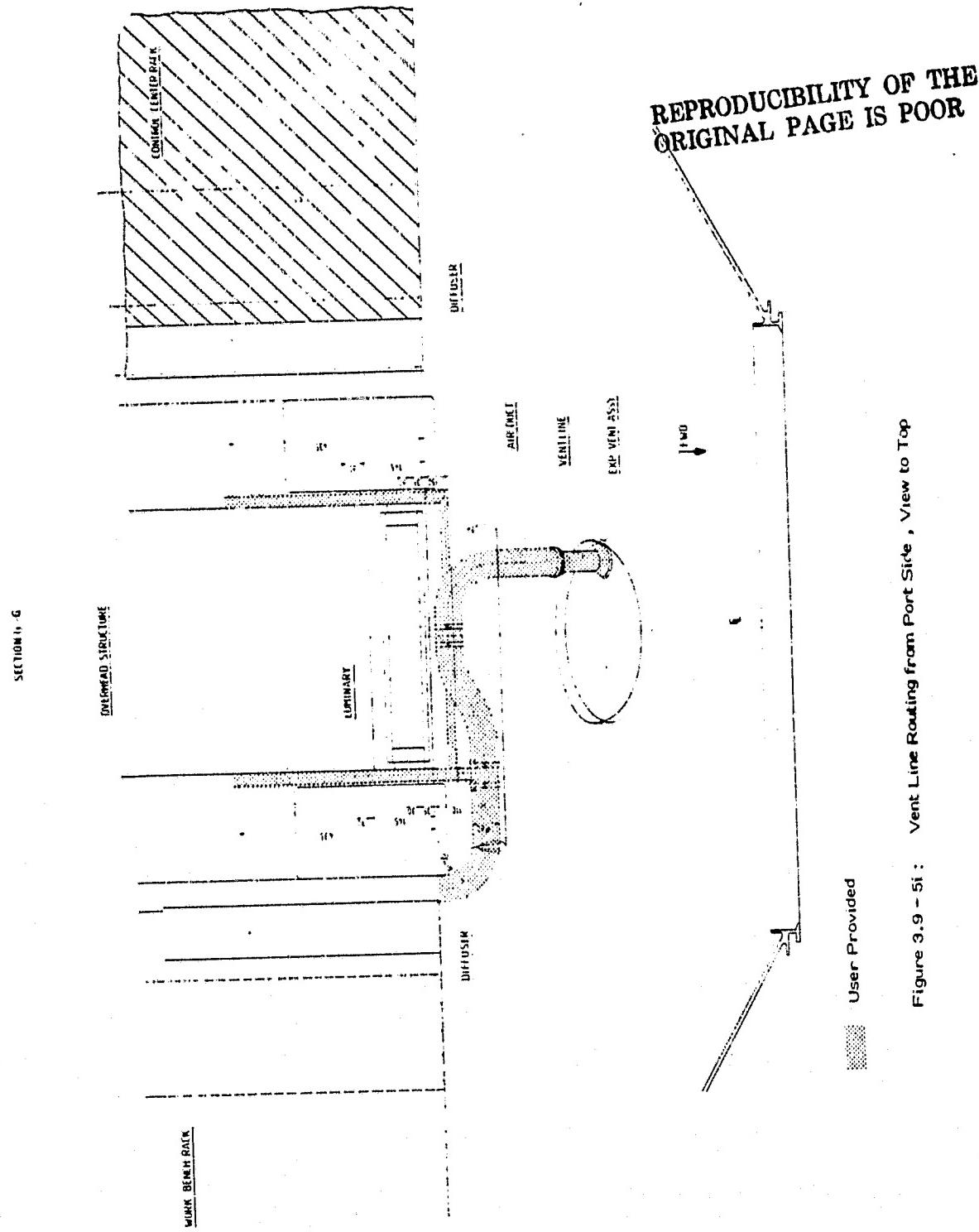
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Figure 3.9 - 5h ; Vent Line Routing from Port Side , Side View

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3.9.2.2 Vent Line Attachment Provisions

For vent line attachments to rack front panel attachment holes can be used, i.e. vent line bracketry is put on top of the front panels of rack equipment and bolted down together with the front panels.

This method is also possible at the control center rack and at the work bench rack as shown in Figure 3.9 - 6. At the work bench rack dedicated holes are provided because there the rack front panel attachment points are covered by the stowage container door.

In the forward end cone area support brackets can be attached to the overhead structure using the overhead stowage container attachment points (see Figures 3.9 - 5d, 5e, 5g, 5h, 5i). For a vent line routed from port side additional attachment to the lamp support structure is possible.

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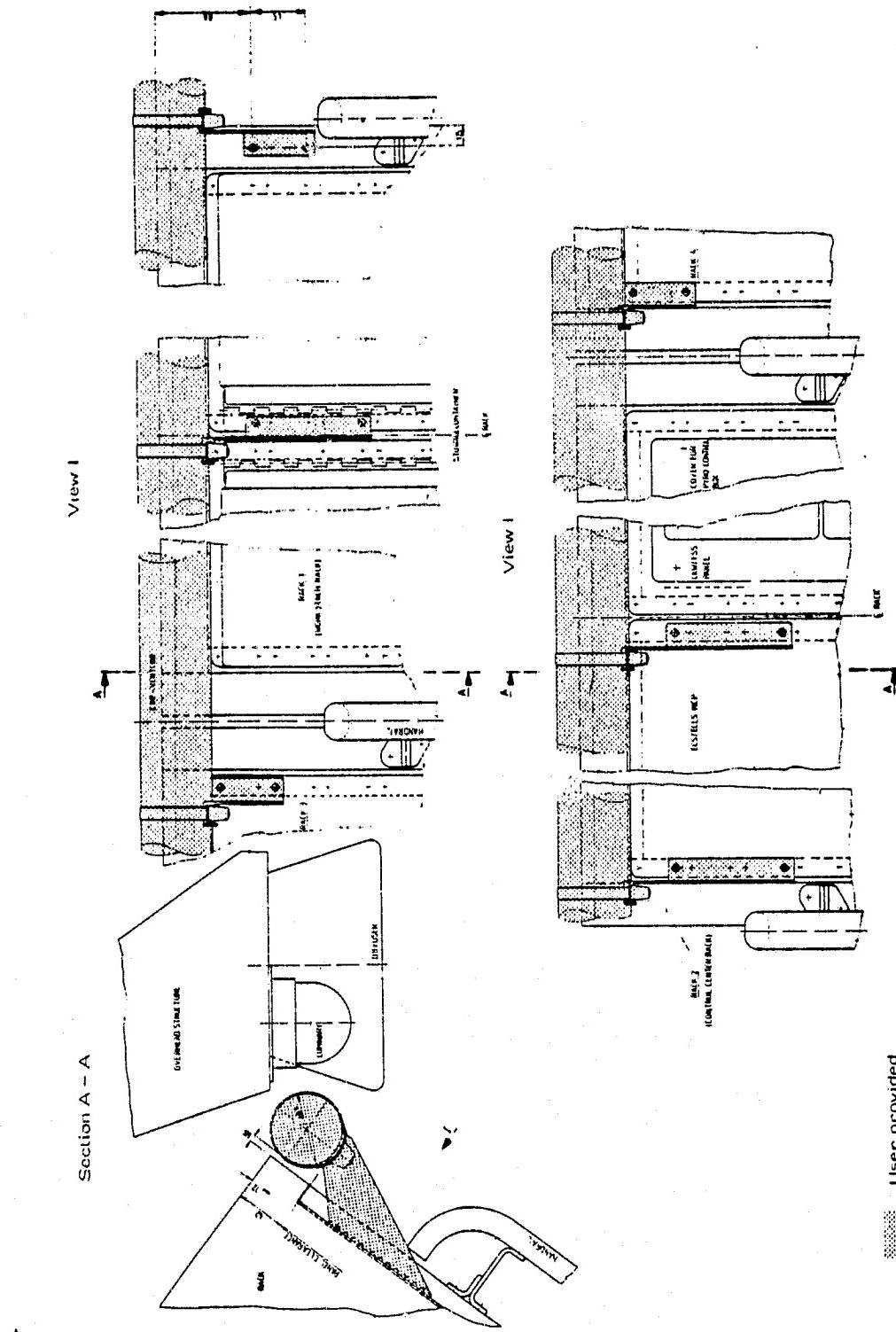


Figure 3.9 - 6: Fastening of Vent Line in the Upper Rack Areas

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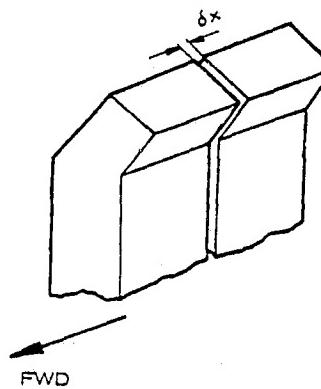
3.9.2.3 Vent Line Design Requirements

The experimenter provided vent line and the related attachment structure must fulfill the following requirements:

- The vent line shall be designed such that it can be easily removed from the experiment vent assembly during on-orbit mission phases.
- The vent line shall have a shut-off valve to shut off the connection to the experiment being vented.
- The vent line shall have a device that allows the repressurisation of the vent line.
- The vent line attachment design shall be capable of accomodating rack to rack and rack to forward end cone deflections as defined in Table 3.9 - 1
- The vent line attachment design shall not preclude the removal of control center rack and work bench rack equipment for maintenance purposes.

Table 3.9 - 1 : Rack / Rack and Rack / Module Shell Deflection

Item	Relative Deflection [mm]			
	+ δx	- δx	$\pm \delta y$	$\pm \delta z$
Single Rack / Double Rack	< 6.8	< 6.8	0.6	< 1.0
Double Rack / Double Rack	6.8	6.8	1.0	< 1.0
WBR / Double Rack	2.0	5.1	< 1.0	< 1.0
CCR / Double Rack	2.0	5.1	< 1.0	< 1.0
CCR / Module Shell	13.2	13.2	N/A	N/A
WBR / Module Shell	13.2	13.2	N/A	N/A



Sign convention:

+ δx = widening
- δx = closure

3.9.3 Experiment Heat Exchanger Secondary Loop Routing

In the following figures possible routing concepts for the experimenter provided plumbing of the secondary loop of the heat exchanger are shown. The liquid line routing shown takes into account various rack 4 configurations, i.e. rack equipped with

- experiment heat exchanger plus module experiment cold plate
- and
- experiment heat exchanger only

and it takes into account the use of the secondary loop in various locations, i.e.

- secondary loop completely inside rack 4
- secondary loop completely outside rack 4
- secondary loop inside and outside rack 4

Also shown is the routing of the secondary loop into the module overhead area.

It should be noted that the secondary loop itself (plumbing and pump), and all necessary support devices - such as brackets, clamps, and fasteners - have to be provided by the experimenter/payload integrator.

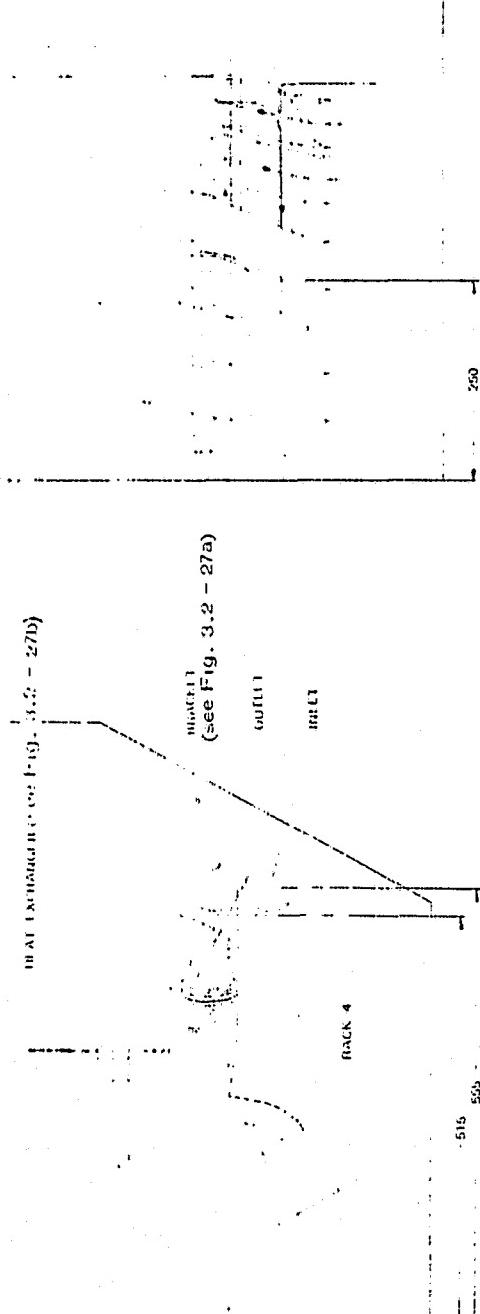
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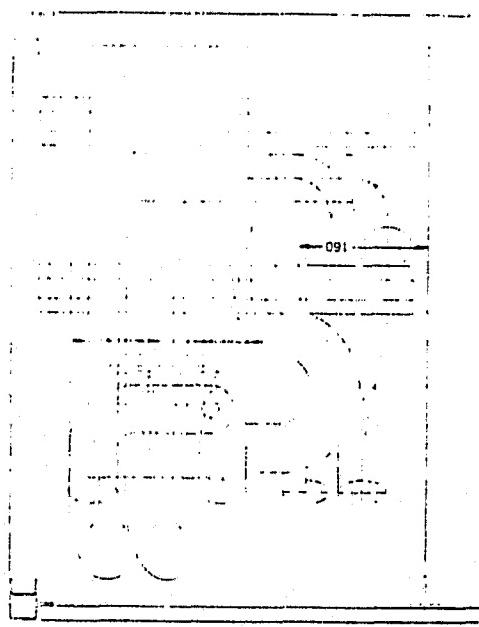
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VIEW I



TOP VIEW



NOTE: Further dimensions are still T B D.

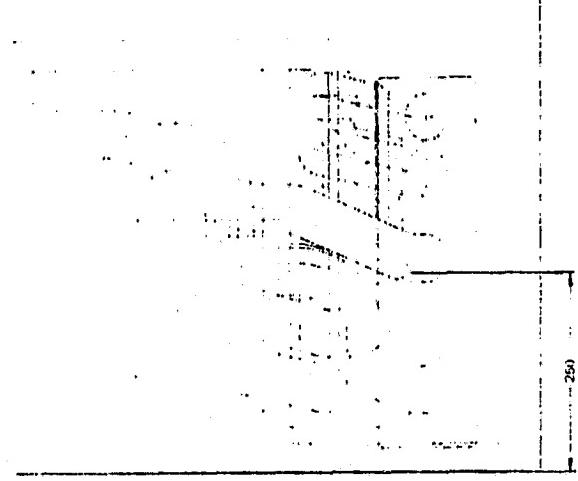
Figure 3.9 - 7a: Rack 4, Heat Exchanger Configuration.

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COLD PLATE (see Fig. 3.2 - 28)

HEAT EXCHANGER
(see Fig. 3.2 - 27b)

BLOCK II
(see Fig. 3.2 - 27a)

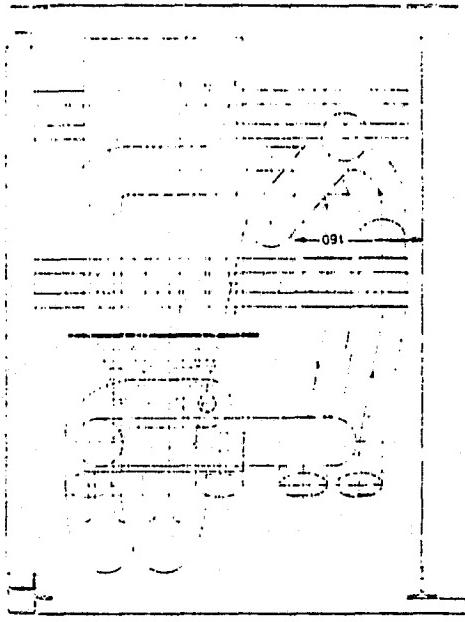
OUTLET

INLET

RACK 4

515 556 250

TOP VIEW



EXP. H/X Set. Loop
(User provided)

NOTE: Further dimensions are still T B D.

Figure 3.9 - 7b: Rack 4, Heat Exchanger / Coldplate Configuration

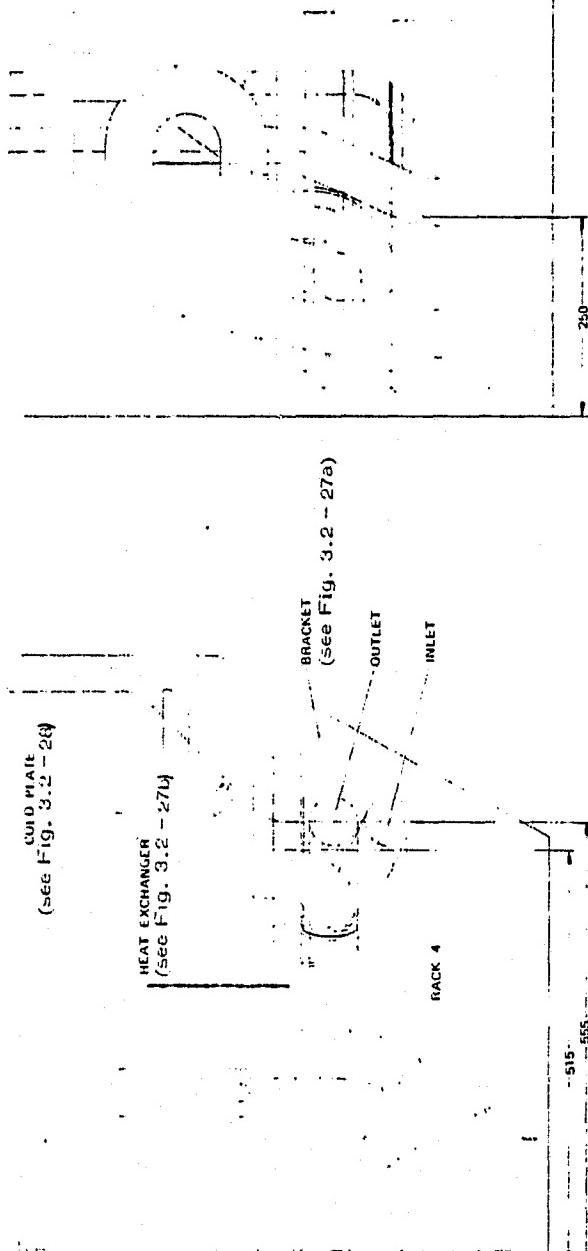
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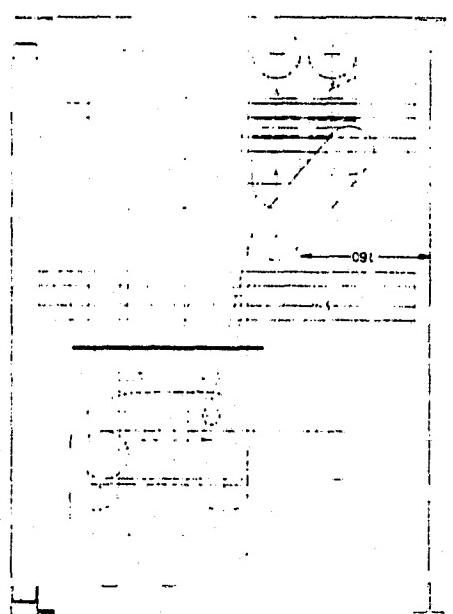
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TOP VIEW



- EXP: H/X Set. Loop
(User provided)

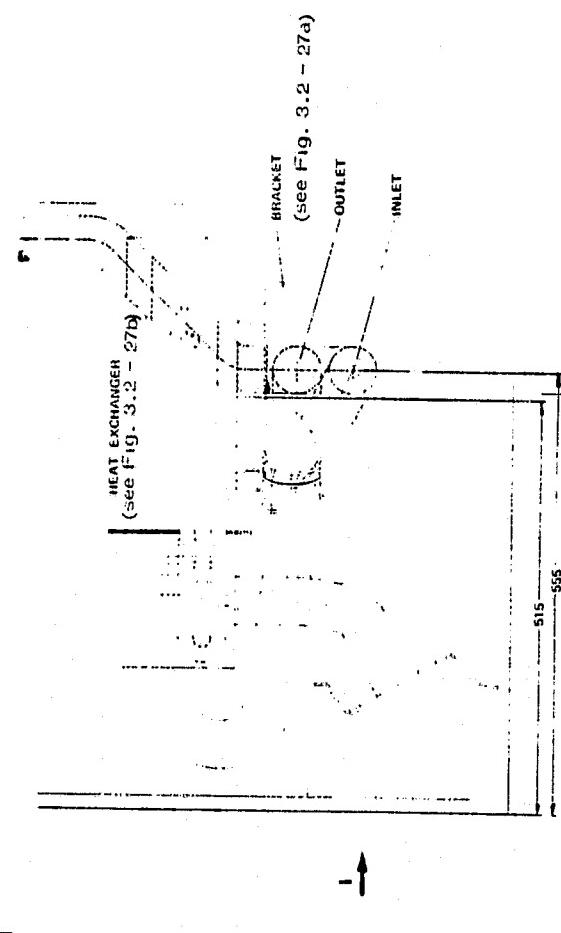
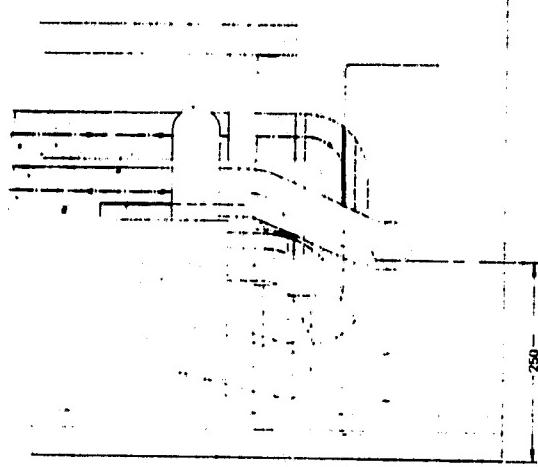
Figure 3.9 - 7c: Rack 4, Heat Exchanger / Coldplate Configuration,
Secondary Loop Inside

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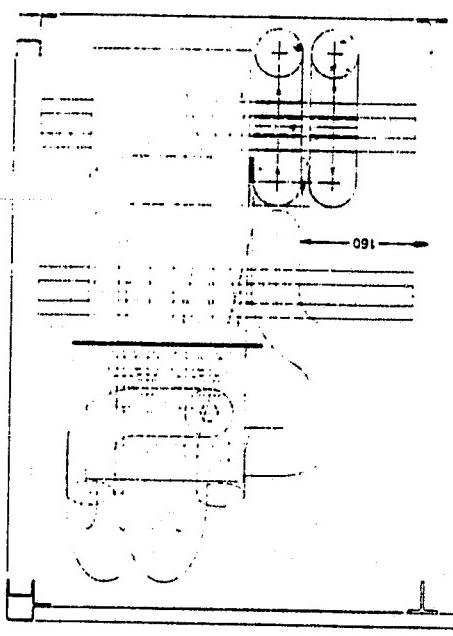
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TOP VIEW

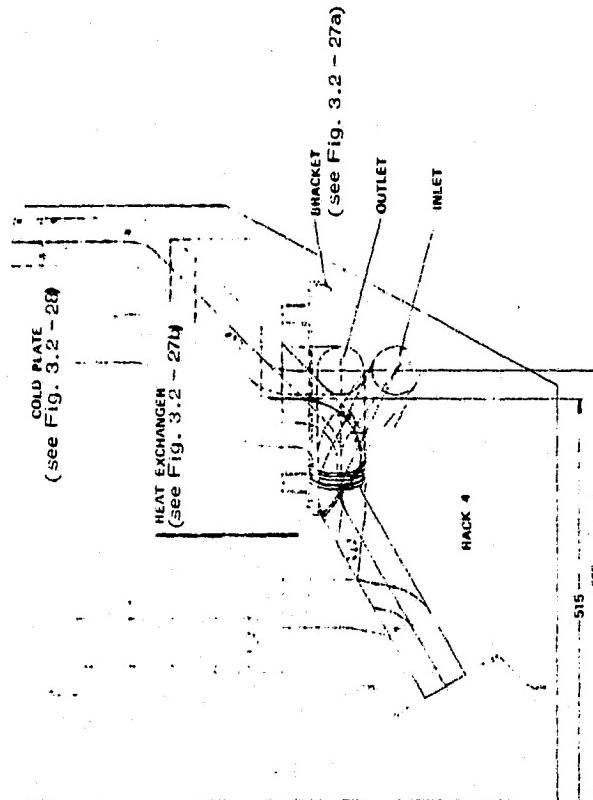
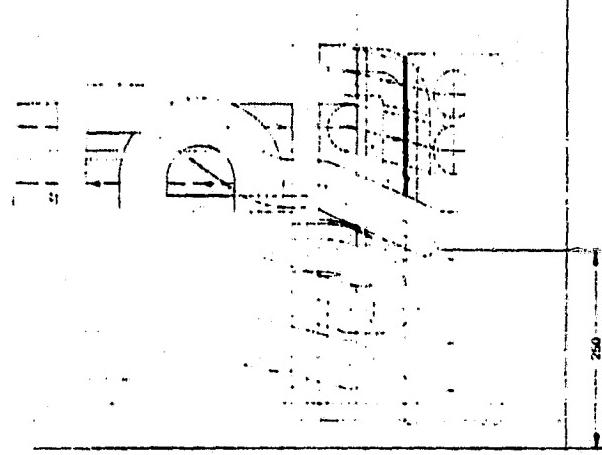


EXP. H/X Sec. Loop
(User provided)

NOTE: Further dimensions are still T.B.D.
Loop Inside

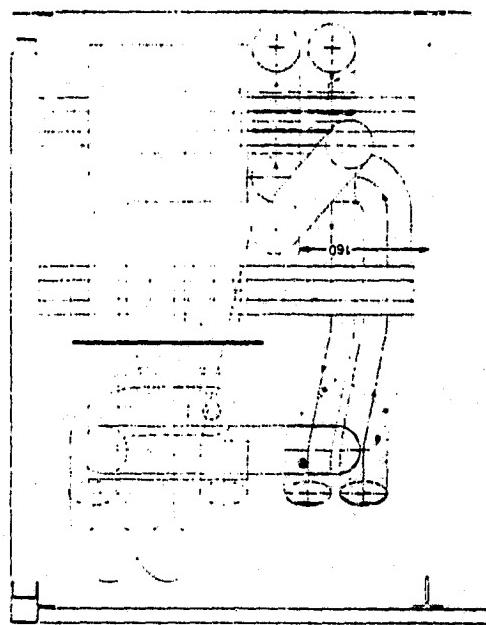
Figure 3.9 - 7d: Rack 4, Heat Exchanger Configuration, Secondary Loop Inside

VIEW 1



B 3.9 - 26

TOP VIEW



NOTE: Further dimensions are still T B D.

- EXP. H / X Sec. Loop
(User provided)

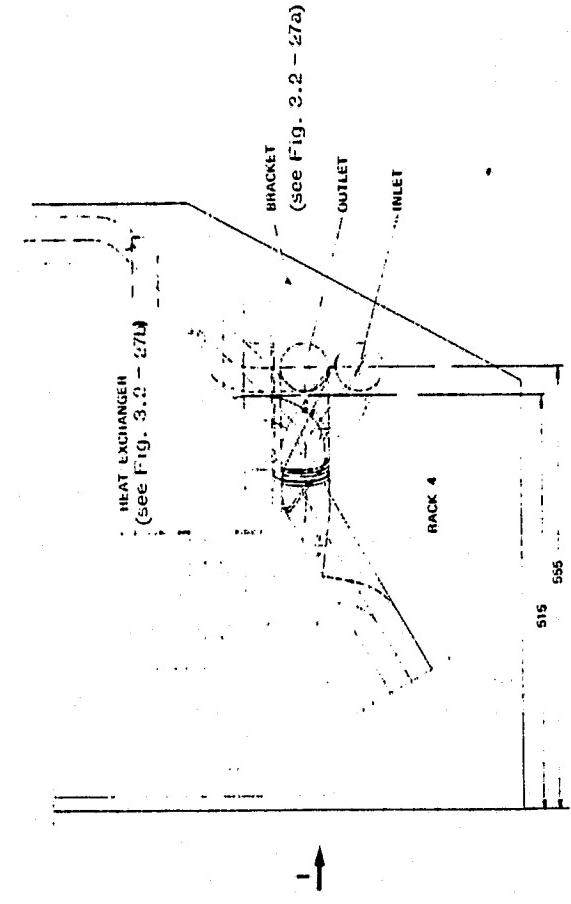
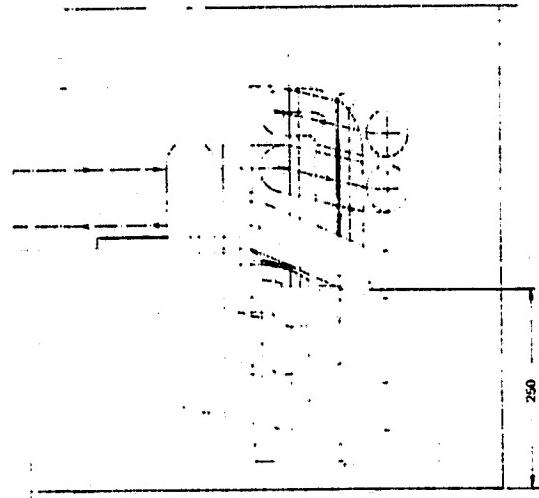
Figure 3.9 - 7e: Rack 4, Heat Exchanger / Coldplate Configuration,
Secondary Loop Inside / Outside

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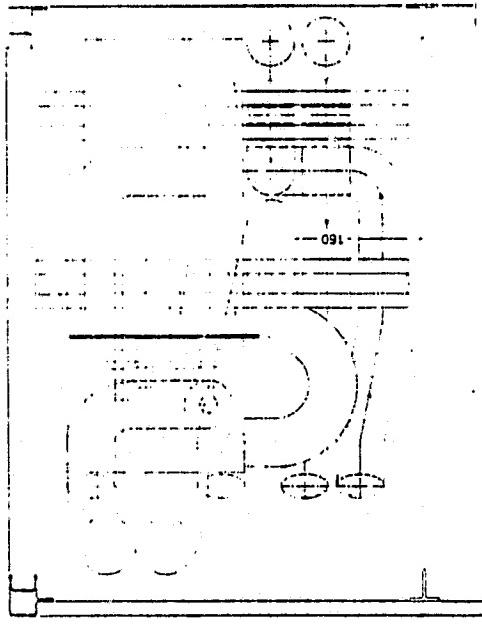
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TOP VIEW



EXP. H/X Sec. Loop
(User provided)

NOTE: Further dimensions are still T B D.

Figure 3.9 - 7f: Rack 4, Heat Exchanger Configuration. Secondary Loop Inside / Outside

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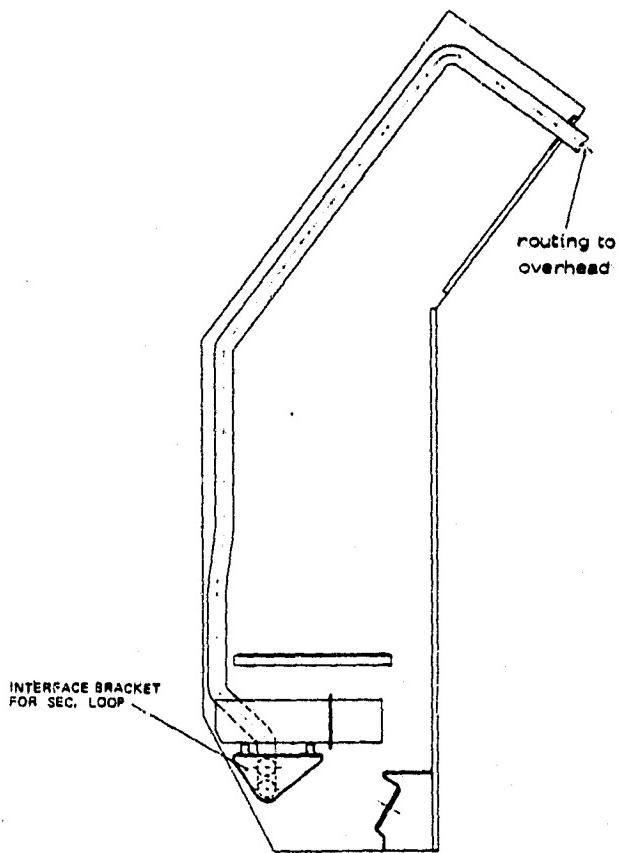
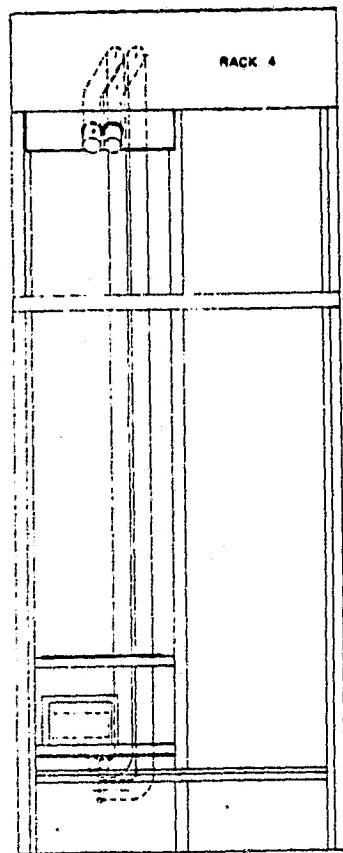
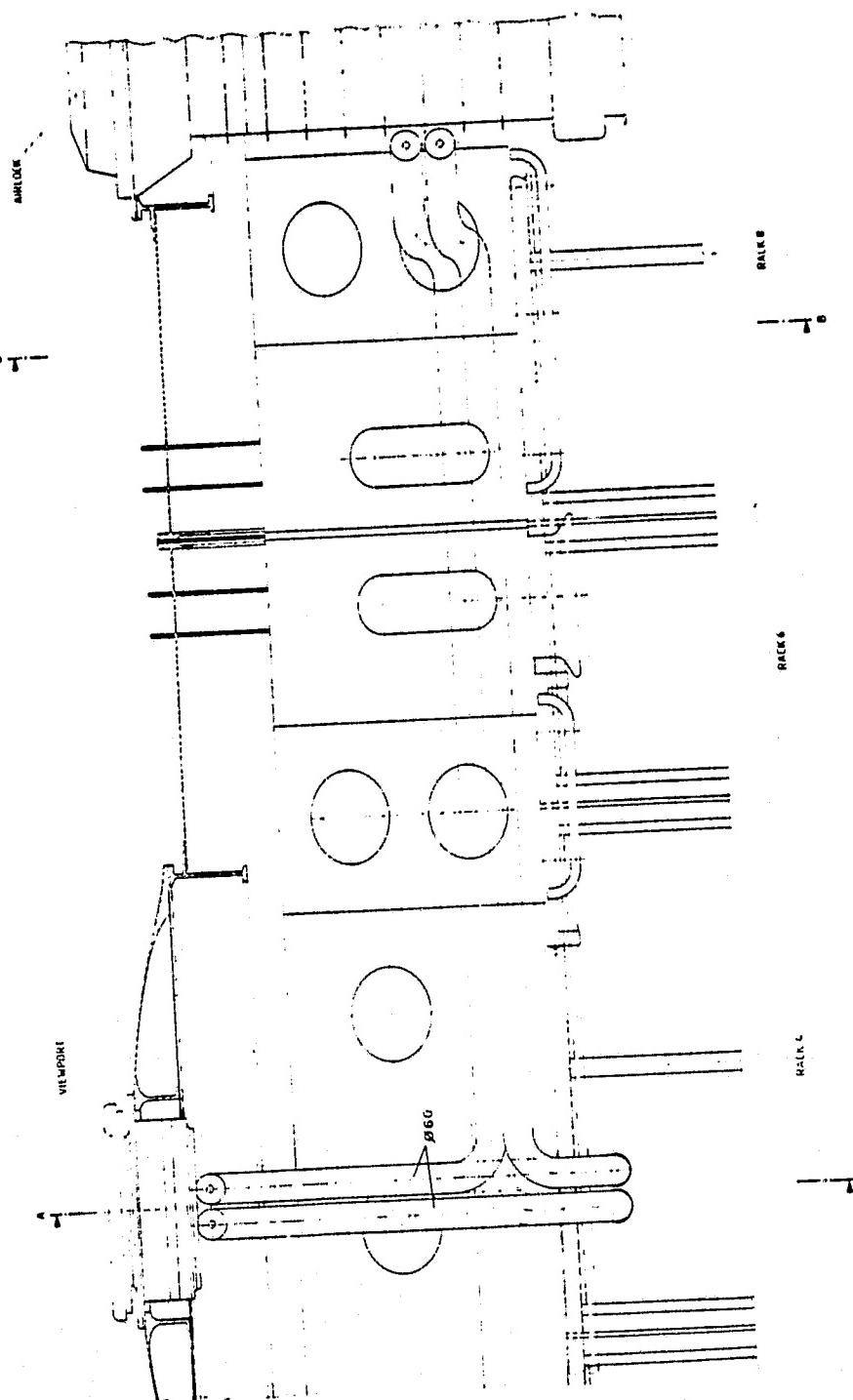


Figure 3.9 - 7g: Sec. Loop from Exp. H/X
To View-Port +

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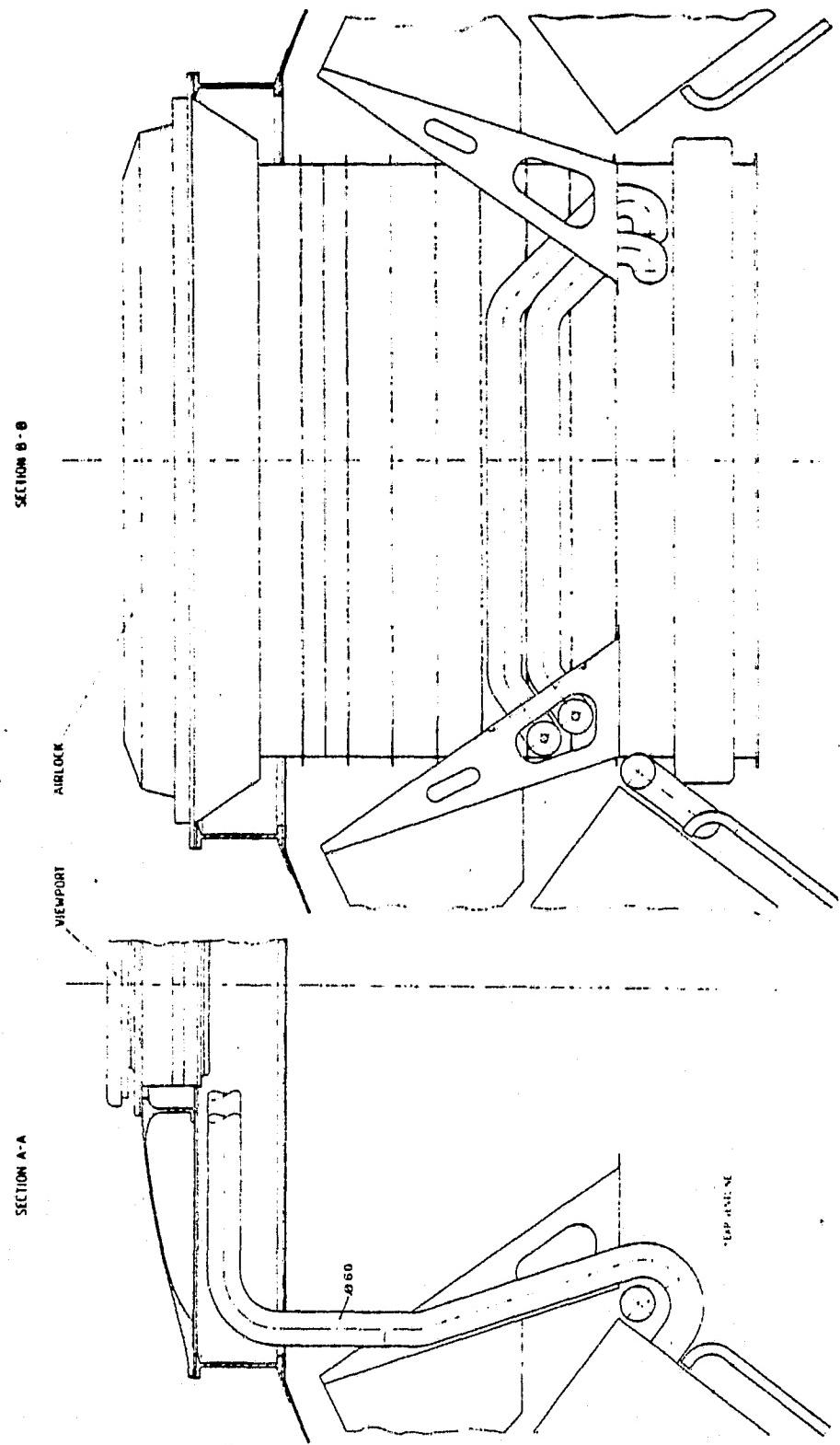
NOTE: Further dimensions are still T B D.

Figure 3.9 - 7H:Exp. Utility Routing Envelopes

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NOTE: Further dimensions are still T B D.

Figure 3.9 - 7f: Exp. Utility Routing Envelopes